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MICHEL EUGENE CHEVREUL.

M. CHEVREUL.

If a chance promenade should lead you some Sunday to the garden of the Museum and into the quiet alleys that skirt the extremity of Cuvier Street, opposite the Seine, you may possibly see, in the second story of a house half hidden by verdure, a venerable man gazing upon the trees, the plants, the flowers, the heavens, and the playing of the children upon the sand. It is M. Chevreul; you will recognize him by his long black surtout and his very white hair, that falls in curls over a pair of shoulders that age has been unable to bend. He has, since the 31st day of last August, been in his ninety-ninth year, and none of the ordinary fatigues of old age seems to have overtaken him. He belongs to the race of oaks.

Here he lives, on Sunday only, at a couple of steps from the Museum where he has so long and so brilliantly taught. The rest of the week he goes, comes, works, and studies the composition of dust in his laboratory at the Gobelins, assists at the meetings of the Academy, presides over the discussions of the National Society of Agriculture, directs the labors of the Consulting Committee of Arts and Manufactures, comments upon Newton and Leibnitz, discusses the labors of his confreres, quarrels with his friend M. Faye *a propos* of his "pirouettes," and, in short, devotes his life and strength to science, which he loves so well.

Recently, when the Academy congratulated M. Chevreul upon his longevity, he said to his colleagues, "I owe it to the moderation of my tastes." This man, in fact, whom a single one of his discoveries might have enriched, and who had only to hold out his hand to gather millions, has been content to pursue his studies and publish the result of them. His professorship, his working cabinet, a few lectures in the library, his conversations with all the illustrious men of the age, these have occupied his life—no luxury, no show, no love of money, nothing but an ardent passion for work. He but rarely leaves his laboratory at the Gobelins, where he has been professor of chemistry and director of the dye houses since 1824. When he enters his apartment near the Museum, he sets himself at work amid the pamphlets and notices with which his room is filled. The room is a modest one, almost severe, with its furniture of the time of the Empire, its old mahogany closet, its little commode—those nothings amid which their owner has passed his busy life. As well known, M. Chevreul calls himself, with charming good nature, the dean of French students. This room of his might also pass for the dean of the rooms of French students. It contains furniture that he certainly owned at the time when, fresh from the Central School of Angers (in 1803), he was studying chemistry at Paris in the Vauquelin manufactory of chemical products. On the walls are a few portraits of friends, a Virgin painted by a relative, and silhouettes of laughing children, all of them objects marked with a souvenir.

We have said that the least of M. Chevreul's discoveries might have procured him a large fortune had he preferred money to science and a desire to be useful. There is one of these which has already put millions into the hands of those who have taken advantage of it, and that is the one that concerns the treatment of fatty bodies and their decomposition into acids and glycerine—a true gold mine. The stearine candle industry was born of this. The dyeing industry, likewise, has profited by those studies upon colors that permitted the illustrious savant to formulate the law of their simultaneous contrast.

M. Chevreul has one of those minds that everything interests, because it sees therein an occasion for verifying or formulating a law, according as the theory explaining this or that phenomenon has or has not been formed. Now, when he took up his labors on colors, the latter had already given rise to interesting observations on the part of the learned Jesuit, Father Scheffert, and these M. Chevreul knew. Father Scheffert had remarked that upon fixing the eyes upon a white surface, after steadily gazing at a colored object, red, for example, the surface assumed, in this case, a green color. Each color gave rise to another, which Father Scheffert called a "reversed" one. These simple observations gave M. Chevreul the idea of seeking all the combinations of colors with each other. The task suited him admirably, for it gave him an occasion to seek an explanation of one of those numerous phenomena of vision. Leibnitz had remarked that "our senses give us only unrealities," and this expression appears to have had a decisive influence upon M. Chevreul's studies. He was the more convinced of the truth of it when he remarked that one color juxtaposed upon another becomes perceptibly modified. In his cabinet he has an album composed of pages of various colors, and upon each of which there is a palm painted in gray. Now this latter appears rose-colored, greenish, orange, etc., according to the color of the page upon which it is painted. Again, red placed beside green appears redder, orange makes blue brighter, and violet is heightened by yellow. This heightening of a color is due to the juxtaposition of its "complementary," for that is the term that M. Chevreul uses as a substitute for Father Scheffert's "reversed." It is the same phenomenon that Leonardo da Vinci witnessed at daybreak, when the shadows of opaque objects appeared to him to be violet.

Besides his curious album, M. Chevreul has his "pirouettes"—a term that is not very scientific, but one that he adheres to notwithstanding the friendly grumbling of M. Faye. These pirouettes, or whirligigs, consist of a disk of cardboard, half white and half colored, traversed in the center by a wire. When this disk is made to revolve, it will, if the colored part is red, appear greenish while in motion; and so with all the other colors, their complementary will appear.

At the present moment, without any interruption in his ordinary work at the Gobelins, M. Chevreul is making a microscopic examination of the dust gathered from various objects with a feather duster. This work he has been at for six months—taking notes and preparing new publications. His memory has in no wise failed him, and if, in speaking of Buffon, for example, you are simply deceived in regard to the date of an edition of one of his works, he will give you at once the exact date of it.

The philosophical uncertainty in which M. Chevreul has always lived has estranged him from all systems. He has remained undisciplined, convinced that nature contains more things than the best philosophies can conceive of. If you speak to him of Saint Simon, the founder of Saint-Simonism, and in whose company he dined at M. De Blainville's, he will tell you that he remembers that the celebrated apostle wore horseman's boots, drawers, and a surtout. If you speak to him of Auguste Comte, he will say to you that the author of positivism was wrong in drawing from the experimental sciences conclusions as exact as from the science of pure reasoning. Press him, in order to get his own idea of optimism and pessimism, and he will give his opinion that neither of these doctrines changes things in any respect; the optimist, who regards everything as beautiful, and the pessimist, who looks at everything as ugly, are not philosophers, but merely peculiar temperaments that see in such or such a manner. The truth is that there is a progress in the sciences, an improvement in social situations, and the old peasants of Anjou, whom M. Chevreul knew, led a harder life than they do to-day.

Finally, ask him what faith he embraces, whether he is a spiritualist, deist, or atheist? He will answer you that no one better than Voltaire has demonstrated the existence of a sole, intelligent power; but that, on another hand, Moliere, who knew many things, painted a very ludicrous personage, the philosopher Marphurius, a man who did not know whether he ought to say the figure or the form of a hat, and who was sure neither of what he saw nor heard until Sganarella beat him with a stick in order to recall him to reality.

And if these answers do not satisfy you, and you insist on knowing the depths of his thought, you will see the great old man put his hands to his forehead as if to disentangle the truth from his compact bundle of knowledge, and then put them out to you smilingly and repeat Montaigne's *mot*, "What know I?"—*L'Illustration.*

The following biographical sketch of this remarkable scientist we find in Appleton's Encyclopædia:

"Chevreul, Michael Eugene, a French chemist, born at Angers, August 31, 1786. Having completed his studies in the Central School of Angers, he studied chemistry under Vauquelin in Paris, and afterward took charge of the laboratory of that chemist. In 1810 he became preparator of the chemical course in the Museum of Natural History, and 1813 professor in the Lycee Charlemagne. In 1824 he was appointed director of the dye works and professor of special chemistry at the Gobelins, where he distinguished himself by his researches on colors. In 1826 he became a member of the Academy of Sciences, and in 1830 succeeded Vauquelin as professor of applied chemistry in the Museum of Natural History. He was afterward made fellow of the Royal Society of London, and president of the Society of Agriculture. In 1851 he was awarded a premium at the London Industrial Exhibition for the benefit his labors had conferred on industry, and 1852 he received from the Society for the Encouragement of Useful Inventions the prize of 12,000 francs for his work, 'Recherches chimiques sur les corps gras d'origine animale,' which had been published in 1823, and which is yet of high value, its suggestions having given rise to the manufacture of stearine candles and to the use of oleic acid in the preparation of wool for cloth. Another work of his, on sanitary influences, introduced the practice of charring the interior of water casks. He was a member of the international jury at the universal exhibition of 1851 in London and of 1855 in Paris. He was appointed director of the Museum of Natural History for five years in 1864 and again in 1869. Besides many articles on scientific subjects in the 'Dictionnaire des sciences naturelles,' the 'Journal des Savants,' and other periodicals, he published numerous works, among which are: 'Lecons de chimie applique a la teinture' (1828-31); 'De la loi du contraste simultane des couleurs et de l'assortement des objets colorees' (1839); 'Des couleurs et de leurs applications aux arts industriels à l'aide des cercles chromatiques' (1864); 'Considerations sur l'histoire de la partie de la medecine qui concerne la prescription des remedes' (1865); and 'Histoire des connaissances chimiques,' the first volume of which appeared in 1866. Many of these works have been translated into various European languages. He has also contributed many important papers to scientific societies, and in 1873, at the age of 86, was still lecturing on chemistry."

THE GENERAL PROGRESS OF CHEMISTRY.*

By Sir H. E. ROSCOE.

With the death of Berzelius in 1848 ended a well-marked epoch in the history of our science; with that of Dumas—and, alas! that of Wurtz also—in 1884 closes a second. It may not perhaps be unprofitable on the present occasion to glance at some few points in the general progress which chemistry has made during this period, and thus to contrast the position of the science in the "sturm und drang" year of 1848 with that in the present, perhaps quieter, period.

The differences between what may probably be termed the Berzelian era and that with which the name of Dumas will forever be associated show themselves in many ways, but in none more markedly than by the distinct views entertained as to the nature of a chemical compound.

According to the older notions, the properties of compounds are essentially governed by a qualitative nature of their constituent atoms, which were supposed to be so arranged as to form a binary system. Under the new ideas, on the other hand, it is mainly the number and arrangement of the atoms within the molecule which regulate the characteristics of the compound, which is to be looked on not as built up of two constituent groups of atoms, but as forming one group.

Among those who successfully worked to secure this important change of view on a fundamental question of chemical theory, the name of Dumas himself must first be mentioned, and, following upon him, the great chemical twin-brethren Laurent and Gerhardt, who, using both the arguments of test-tube and of pen in opposition to the prevailing views, gradually succeeded, though scarcely during the lifetime of the first, in convincing chemists that the condition of things could hardly be a healthy one when chemistry was truly defined "as the science of bodies which do not exist." For Berzelius, adhering to his preconceived notions, had been forced by the pressure of new discovery into the adoption of formulæ which gradually became more and more complicated, and led to more and more doubtful hypotheses, until his followers at last could barely succeed in building up the original radical from its numerous supposed component parts. Such a state of things naturally brought about its own cure, and the unitary formulæ of Gerhardt began to be generally adopted.

It was not, however, merely as an expression of the nature of the single chemical compound that this change was beneficial, but, more particularly, because it laid open the general analogies of similarly constituted compounds, and placed fact as the touch-stone by which the constitution of these allied bodies should be ascertained. Indeed, Gerhardt, in 1852, gave evidence of the truth of this in his well-known theory of type, according to which organic compounds of ascertained constitution can be arranged under the four types of hydrogen, hydrochloric acid, water, and ammonia, and of which it is, perhaps, not too much to say that it has, more than any other of its time, contributed to the clearer understanding of the relations existing among chemical compounds.

Another striking difference of view between the chemistry of the Berzelian era and that of what we sometimes term the modern epoch is illustrated by the so-called substitution theory. Dumas, to whom we owe this theory, showed that chlorine can take the place of hydrogen in many compounds, and that the resulting body possesses characters similar to the original. Berzelius opposed this view, insisting that the essential differences between these two elements rendered the idea of a substitution impossible, and notwithstanding the powerful advocacy of Liebig, and the discovery by Melsens of reverse substitutions (that is, the reformation of the original compound from its substitution product), Berzelius remained to the end unconvinced; and that which was in reality a confirmation of his own theory of compound radicals, which, as Liebig says, "illumined many a dark chapter in organic chemistry," was looked upon by him as an error of the deepest dye. This inability of many minds to see in the discoveries of others confirmation of their own views is not uncommon; thus Dalton, we may remember, could never bring himself to admit the truth of Gay-Lussac's laws of gaseous volume-combination, although, as Berzelius very truly says, if we write *atom* for *volume*, and consider the substance in the solid state in place of the state of gas, the discovery of Gay-Lussac is seen to be one of the most powerful arguments in favor of Dalton's hypothesis.

But there is another change of view, dating from the commencement of the Dumas epoch, which has exerted an influence equal, if not superior, to those already named on the progress of our science. The relative weights of the ultimate particles, to use Dalton's own words, which up to this time had been generally adopted by chemists, were the equivalent weights of Dalton and Wollaston, representing, in the case of oxygen and hydrogen, the proportions in which these elements combine, viz., as 8 to 1. The great Swedish chemist at this time stood almost alone in supporting another hypothesis; for, founding his argument on the simple laws of volume-combination enunciated by Gay-Lussac, he asserted that the true atomic weights are to be represented by the relations existing between equal volumes of the two gases, viz., as 16 to 1. Still these views found no favor in the eyes of chemists until Gerhardt, in 1843, proposed to double the equivalent weights of oxygen, sulphur, and carbon, and then the opposition which this suggestion met with was most intense, Berzelius himself not even deigning to mention it in his annual account of the progress of the science, thus proving the truth of his own words: "That to hold an opinion habitually often leads to such an absolute conviction of its truth that its weak points are unregarded, and all proofs against it ignored." Nor were these views generally adopted by chemists until Cannizaro, in 1858, placed the whole subject on its present firm basis by clearly distinguishing between equivalent and molecular weights, showing how the atomic weights of the constituent elements are derived from the molecular weights of their volatile compounds based upon the law of Avogadro and Ampere, or where, as is the case with many metals, no compounds of known vapor density exist, how the same result may be ascertained by the help of the specific heat of the element itself. Remarkable as it may appear, it is nevertheless true that it is in the country of their birth that Gerhardt's atomic weights and the consequent atomic nomenclature have met with most opposition, so much so that within a year or two of the present time there was not a single course of lectures delivered in Paris in which these were used.

The theory of organic radicals, developed by Liebig so long ago as 1834, received numerous experimental confirmations in succeeding years. Bunsen's classical research on cacodyl, proving the possibility of the existence of metallo-organic radicals capable of playing the part of a metal, and the isolation of the hydrocarbon ethyl by Frankland in 1849, laid what the supporters of the theory deemed the final stone in the structure.

The fusion of the radical and type theories, chiefly effected by the discovery of 1849 of the compound ammonias by Wurtz, brings us to the dawn of modern chemistry. Henceforward organic compounds were seen to be capable of comparison with simple inorganic bodies, and hydrogen not only capable of replacement by chlorine or by a metal, but by an organic group or radical.

To this period my memory takes me back. Liebig at Giessen, Wohler in Gottingen, Bunsen in Marburg, Dumas, Wurtz, and Laurent and Gerhardt in Paris, were the active spirits in Continental chemistry. In our own country, Graham, whose memorable researches on the phosphates had enabled Liebig to found his theory of polybasic acids, was working and lecturing at University College, London; and Williamson, imbued with the new doctrines and views of the twin French chemists, had just been appointed to the Chair of Practical Chemistry in the same college, vacant by the death of poor Fownes. At the same time, Hofmann, in whom Liebig found a spirit as enthusiastic in the cause of scientific progress as his own, bringing to England a good share of the Giessen fire, founded the most successful school of chemistry which this country has yet seen.

At the Edinburgh meeting of this Association in 1850, Williamson read a paper on "Results of a Research on Ætherification," which included not only a satisfactory solution of an interesting and hitherto unexplained problem, but was destined to exert a most important influence on the development of our theoretical views. For he proved, contrary to the then prevailing ideas, that ether contains twice as much carbon as alcohol, and that it is not formed from the latter by a mere separation of the elements of water, but by an exchange of hydrogen for ethyl, and this fact being in accordance with Avogadro's law of molecular volumes, could only be represented by regarding the molecule of water as containing two atoms of hydrogen to one of oxygen, one of the former being replaced by one of ethyl to form alcohol, and the two of hydrogen by two of ethyl to form ether. Then Williamson introduced the type of water (subsequently adopted by Gerhardt) into organic chemistry, and extended our views with the analogies between alcohols and acids, by pointing out that these latter are also referable to the water-type, predicting that bodies bearing the same relations to the ordinary acids as the ethers do to the alcohols must exist, a prediction shortly afterward (1852) verified by Gerhardt's discovery of the anhydrides. Other results followed in rapid succession, all tending to knit together the framework of modern theoretical chemistry. Of these the most important was the adoption of condensed types of compounds constructed on the type of two and three molecules of water, with which the names of Williamson and Odling are connected, culminating in the researches of Brodie on the higher alcohols, of Berthelot on

* Opening address by Prof. Sir Henry Enfield Roscoe, Ph.D., LL.D., F.R.S., F.C.S., President of Section B, Chemical Science, of British Association, Montreal.

glycerine, and of Wurtz on the dibasic alcohols or glycols; while, in another direction, the researches of Hofmann on the compound amines and amides opened out an entirely new field, showing that either a part or the whole of the hydrogen in ammonia can be replaced by other elements or elementary groups without the type losing its characteristic properties.

Again, in 1852, we note the first germs of a theory which was destined to play an all-important part in the progress of the science, viz., the doctrine of valency or atomicity, and to Frankland it is that we owe this new departure. Singularly enough, while considering the symmetry of construction visible among the inorganic compounds of nitrogen, phosphorus, arsenic, and antimony, and while putting forward the fact that the combining power of the attracting element is always satisfied by the same number of atoms, he does not point out the characteristic tetrad nature of carbon; and it was not until 1858 that Couper initiated, and Kekulé, in the same year, thoroughly established, the doctrine of the linking of the tetrad carbon atoms, a doctrine to which, more than to any other, is due the extraordinary progress which organic chemistry has made during the last twenty years—a progress so vast that it is already found impossible for one individual, even though he devote his whole time and energies to the task, to master all the details, or make himself at home with the increasing mass of new facts which the busy workers in this field are daily bringing forth.

The subject of the valency of the elements is one which, since the year above referred to, has given chemists much food for discussion, as well as opportunity for experimental work. But whether we range ourselves with Kekule, who supports the unalterable character of the valency of each element, or with Frankland, who insists on its variability, it is now clear to most chemists that the hard and fast lines upon which this theory was supposed to stand cannot be held to be secure. For if the progress of investigation has shown that it is impossible in many instances to affix one valency to an element which forms a large number of different compounds, it is also equally impossible to look on the opposite view as tending toward progress, inasmuch as to ascribe to an element as many valencies as it possesses compounds with some other element is only expressing by circuitous methods what the old Daltonian law of combination in multiple proportion states in simple terms. Still we may note certain generally accepted conclusions: in the first place, that of the existence of non-saturated compounds, both inorganic and organic, as carbon-monoxide on the one hand, and malic and citraconic acids on the other. Secondly, that the valency of an element is not only dependent upon the nature of the element with which it combines, but that this valency is a periodic function of the atomic weight of the other component. Thus the elements of the chlorine group are always monads when combined with positive elements or radicals, but triad, pentad, and heptad with negative ones. Again, the elements of the sulphur group are dyads in the first case, but tetrad and hexad in the second. The periodicity of this property of the atoms, increasing and again diminishing, is clearly seen in such a series as

$$AgCl, CdCl_2, InCl_3, SnCl_4, SbH_3, TeH_2, IH,$$

as well as in the series of oxides. The difficulties which beset this subject may be judged of by the mention of a case or two: Is vanadium a tetrad because its highest chloride contains four atoms of chlorine? What are we to say is the valency of lead when one atom unites with four methyls to form a volatile product, and yet the vapor-density of the chloride shows that the molecule contains one of metal to two of chlorine? Or, how can our method be said to determine the valency of tungsten when the hexachloride decomposes in the state of vapor, and the pentachloride is the highest volatile stable compound? How again are we to define the point at which a body is volatile without decomposition? Thus sulphur tetrachloride, one of the most unstable of compounds, can be vaporized without decomposition at all temperatures below —22°, while water, one of the most stable of known compounds, is dissociated into its elements at the temperature of melting platinum.

But, however many doubts may have been raised in special instances against a thorough application of the law of valency, it cannot be denied that the general relations of the elements which this question of valency has been the means of bringing to light are of the highest importance, and point to the existence of laws of nature of the widest significance; I allude to the periodic law of the elements first foreshadowed by Newlands, but fully developed by Mendeljeff and Lothar Meyer. Guided by the principle that the chemical properties of the elements are a periodic function of their atomic weights, or that matter becomes endowed with analogous properties when the atomic weight of an element is increased by the same or nearly the same number, we find ourselves for the first time in possession of a key which enables us to arrange the hitherto *disjecta membra* of our chemical household in something like order, and thus gives us means of indicating the family resemblances by which these elements are characterized.

And here we may congratulate ourselves on the fact, that by the recent experiments of Brauner, and of Nilson and Pettersen respectively, tellurium and beryllium, two of the hitherto outstanding members, have been induced to join the ranks, so that at the present time osmium is the only important defaulter among the sixty-four elements, and few persons will doubt that a little careful attention to this case will remove the stigma which yet attaches to its name. But this periodic law makes it possible for us to do more; for as the astronomer, by the perturbations of known planets, can predict the existence of hitherto unknown ones, so the chemist, though, of course, with much less satisfactory means, has been able to predict with precision the properties, physical and chemical, of certain missing links among the elements, such as ekaluminium and ekaboron, then unborn, but which shortly afterward became well known to us in the flesh as gallium and scandium. We must, however, take care that success in a few cases does not blind us to the fact that the law of nature which expresses the relation between the properties of the elements and the value of the atomic weights is as yet unknown; that many of the groupings are not due to any well ascertained analogy of properties of the elements, and that it is only because the values of their atomic weights exhibit certain regularities that such a grouping is rendered possible. So, to quote Lothar Meyer, we shall do well in this, as indeed in all similar cases in science, to remember the danger pointed out in Bacon's aphorism, that "The mind delights in springing up to the most general axioms, that it may find rest, but after a short stay here it disdains experience," and to bear in mind that it is only the lawful union of hypothesis with experiment which will prove a fruitful one in the establishment of a systematic inorganic chemistry which need not fear comparison with the order which reigns in the organic branch of our science. And here it is well to be reminded that complexity of constitution is not the sole prerogative of the carbon compounds, and that before this systematization of inorganic chemistry can be effected we shall have to come to terms with many compounds concerning whose constitution we are at present wholly in ignorance. As instances of such I would refer to the finely crystalline phospho-molybdates, containing several hundred atoms in the molecule, lately prepared by Wolcott Gibbs.

Arising out of Kekule's theory of the tetrad nature of the carbon atom, came the questions which have caused much debate among chemists: (1) are the four combining units of the carbon atom of equal value or not? And (2) is the assumption of a dyad carbon atom in the so-called non-saturated compounds justifiable or not? The answer to the first of these, a favorite view of Kolbe's, is given in the now well ascertained laws of isomerism; and from the year 1862, when Schorlemmer proved the identity of the hydrides of the alcohol radicals with the so-called radicals themselves, this question may be said to have been set at rest; for Lossen himself admits that the existence of his singular isomeric hydroxylamine derivatives can be explained otherwise than by the assumption of a difference between each of the combining units of nitrogen, and the differences supposed by Schreiner to hold good between the methyl-ethyl carbonic ethers have been shown to have no existence in fact. With respect to the second point the reply is no less definite, and is recorded in the fact, among others, that ethylene chlorhydrin yields on oxidation chloracetic acid, a reaction which cannot be explained on the hypothesis of the existence in ethylene of a dyad carbon atom.

Passing from this subject, we arrive, by a process of natural selection, at more complicated cases of chemical orientation—that is, given certain compounds which possess the same composition and molecular formulæ, but varying properties, to find the difference in molecular structure by which such variation of properties is determined. Problems of this nature can now be satisfactorily solved, the number of possible isomers foretold, and this prediction confirmed by experiment. The general method adopted in such an experimental inquiry into the molecular arrangement or chemical constitution of a given compound is either to build up the structure from less complicated ones of known constitution, or to resolve it into such component parts. Thus, for example, if we wish to discriminate between several isomeric alcohols, distinguishing the ordinary or primary class from the secondary or tertiary class, the existence of which was predicted by Kolbe in 1862, and of which the first member was prepared by Friedel in 1864, we have to study their products of oxidation. If one yields an acid having the same number of carbon atoms as the alcohol, it belongs to the first class, and possesses a definite molecular structure; if it splits up into two distinct carbon compounds, it is a secondary alcohol; and if three carbon compounds result from its oxidation, it must be classed in the third category, and to it belongs a definite molecular structure, different from that of the other two

In a similar way orientation in the much more complicated aromatic hydrocarbons can be effected. This class of bodies forms the nucleus of an enormous number of carbon compounds, which, both from a theoretical and a practical point of view, are of the highest interest. For these bodies exhibit characters and possess a constitution totally different from those of the so-called fatty substances, the carbon atoms being linked together more intimately than is the case in the latter named group of bodies. Among them are found all the artificial coloring matters, and some of the most valuable pharmaceutical and therapeutical agents.

The discovery of the aniline colors by Perkin, their elaboration by Hofmann, the synthesis of alizarin by Graebe and Liebermann, being the first vegetable coloring matter which has been artificially obtained, the artificial production of indigo by Baeyer, and lastly the preparation, by Fischer, of kairin, a febrifuge as potent as quinine, are some of the well known recent triumphs of modern synthetical chemistry. And these triumphs, let us remember, have not been obtained by any such "random haphazarding" as yielded results in Priestley's time. In the virgin soil of a century ago, the ground only required to be scratched and the seed thrown in to yield a fruitful crop; now the surface soil has long been exhausted, and the successful cultivator can only obtain results by a deep and a thorough preparation, and by a systematic and scientific treatment of his material.

In no department of our science has the progress made been more important than in that concerned with the accurate determination of the numerical, physical, and chemical constants, upon the exactitude of which every quantitative chemical operation depends. For the foundation of an accurate knowledge of the first of these constants, viz., the atomic weights of the elements, science is indebted to the indefatigable labors of Berzelius. But "humanum est errare," and even Berzelius' accurate hand and delicate conscientiousness did not preserve him from mistakes, since corrected by other workers. In such determinations it is difficult, if not impossible, always to ascertain the limits of error attaching to the number. The errors may be due in the first place to manipulative faults, in the second to inaccuracy of the methods, or lastly to mistaken views as to the composition of the material operated upon; and hence the uniformity of any series of similar determinations gives no guarantee of their truth, the only safe guide being the agreement of determinations made by altogether different methods. The work commenced by Berzelius has been worthily continued by many chemists. Stas and Marignac, bringing work of an almost astronomical accuracy into our science, have ascertained the atomic weights of silver and iodine to within one hundred-thousandth of their value, while the numbers for chlorine, bromine, potassium, sodium, nitrogen, sulphur, and oxygen may now be considered to be correct to within a unit in the fourth figure. Few of the elements, however, boast numbers approaching this degree of accuracy, and many may even still be erroneous from half to a whole unit of hydrogen. And, as Lothar Meyer says, until the greater number of the atomic weights are determined to within one or two tenths of the unit, we cannot expect to be able to ascertain the laws which certainly govern these numbers, or to recognize the relations which undoubtedly exist between them and the general chemical and physical properties of the elements. Among the most interesting recent additions to our knowledge made in this department we may note the classical experiments, in 1880, of J. W. Mallet on aluminum, and in the same year of J. P. Cooke on antimony, and those, in the present year, of Thorpe on titanium.

Since the date of Berzelius' death to the present day, no discovery in our science has been so far-reaching, or led to such unforeseen and remarkable conclusions, as the foundation of spectrum analysis by Bunsen and Kirchhoff in 1860.

Independently altogether of the knowledge which has been gained concerning the distribution of the elementary bodies in terrestrial matter, and of the discovery of half a dozen new elements by its means, and putting aside for a moment the revelation of a chemistry not bounded by this world, but limitless as the heavens, we find that over and above all these results spectrum analysis offers the means, not otherwise open to us, of obtaining knowledge containing the atomic and molecular condition of matter.

Let me recall some of the more remarkable conclusions to which the researches of Lockyer, Schuster, Liveing and Dewar, Wullner, and others in this direction have led. In the first place it is well to bear in mind that a difference of a very marked kind, first distinctly pointed out by Alex. Mitscherlich, is to be observed between the spectrum of an element and that of its compounds, the latter only being seen in cases in which the compound is not dissociated at temperatures necessary to give rise to a glowing gas. Secondly, that these compound spectra—as, for instance, those of the halogen compounds of the alkaline earth metals—exhibit a certain family likeness, and show signs of systematic variation in the position of the lines, corresponding to changes in the molecular weight of the vibrating system. Still this important subject of the relation of the spectra of different elements is far from being placed on a satisfactory basis; and in spite of the researches of Lecoq de Boisbaudran, Ditte, Troost and Hautefeuille, Ciamician, and others, it cannot be said that as yet definite proof has been given in support of the theory that a casual connection is to be found between the emission spectra of the several elements belonging to allied groups and their atomic weights or other chemical or physical properties. In certain of the single elements, however, the connection between the spectra and the molecular constitution can be traced. In the case of sulphur, for example, three distinct spectra are known. The first of these, a continuous one, is exhibited at temperatures below 500°, when, as we know from Dumas' experiments, the density of the vapor is three times the normal, showing that at this temperature the molecule consists of six atoms. The second spectrum is seen when the temperature is raised to above 1,000°, when, as Deville and Troost have shown, the vapor reaches its normal density, and the molecule of sulphur, as with most other gases, contains two atoms, and this is a band spectrum, or one characterized by channeled spaces. Together with this band spectrum, and especially around the negative pole, a spectrum of bright lines is observed. This latter is doubtless due to the vibrations of the single atoms of the dissociated molecule, the existence of traces of a band spectrum demonstrating the fact that in some parts of the discharge the tension of dissociation is insufficient to prevent the reunion of the atoms to form the molecule.

To this instance of the light thrown on molecular relations by changes in the spectra, others may be added. Thus the low temperature spectrum of channeled spaces, mapped by Schuster and myself, in the case of potassium, corresponds to the molecule of two atoms and to the vapor density of 79 observed by Dewar and Dittmar. Again, both oxygen and nitrogen exhibit two, if not three, distinct spectra; of these the line spectrum seen at the highest temperatures corresponds to the atom; the band spectrum seen at intermediate temperatures represents the molecule of two atoms; while that observed at a still lower point would, as in the case of sulphur, indicate the existence of a more complicated molecule, known to us in one instance as ozone.

That this explanation of the cause of these different spectra of an element is the true one, can be verified in a remarkable way. Contrary to the general rule among those elements which can readily be volatilized, and with which, therefore, low temperature spectra can be studied, mercury exhibits but one spectrum, and that one of bright lines, or, according to the preceding theory, a spectrum of atoms. So that, judging from spectroscopic evidence, we infer that the atoms of mercury do not unite to form a molecule, and we should predict that the vapor density of mercury is only half its atomic weight. Such we know, from chemical evidence, is really the case, the molecule of mercury being identical in weight with its atom.

The cases of cadmium and iodine require further elucidation. The molecule of gaseous cadmium, like that of mercury, consists of one atom; probably, therefore, the cadmium spectrum is also distinguished by one set of lines. Again, the molecule of iodine at 1,200° separates, as we know from Victor Meyer's researches, into single atoms. Here spectrum analysis may come again to our aid; but, as Schuster remarks, in his report on the spectra of the non-metallic elements, a more extensive series of experiments than those already made by Ciamician is required before any definite opinion as to the connection of the different iodine spectra with the molecular condition of the gas can be expressed.

It is not to be wondered at that these relations are only exhibited in the case of a few elements. For most of the metals the vapor density remains, and probably will remain, an unknown quantity, and therefore the connection between any observed changes in the spectra and the molecular weights must also remain unknown. The remarkable changes which the emission spectrum of a single element—iron, for instance—exhibits have been the subject of much discussion, experimental and otherwise. Of these, the phenomenon of long and short lines is one of the most striking, and the explanation that the long lines are those of low temperature appears to meet the fact satisfactorily, although the effect of dilution, that is, a reduction of the quantity of material undergoing volatilization, is, remarkably enough, the same as that of diminution of temperature. Thus it is possible, by the examination of a spectrum by Lockyer's method, to predict the changes which it will undergo, either on alteration of temperature or by an increase or decrease of quantity. There appears to be no theoretical difficulty in assuming that the relative intensity of the lines may vary when the temperature is altered, and the molecular theory of gases furnishes us with a plausible explanation of the corresponding change when the relative quantities of the luminous elements in a mixture are altered.

Lockyer has proposed a different explanation of the facts. According to him, every change of relative intensity means a corresponding change of molecular complexity, and the lines which we see strong near the poles would bear the same relation to those which are visible throughout the field as a line spectrum bears to a band spectrum; but then almost every line must be due to a different molecular grouping, a conclusion which is scarcely capable of being upheld without very cogent proof.

The examination of the absorption spectra of salts, saline and organic liquids, first by Gladstone, and afterward by Bunsen and by Russell, as well as by Hartley for the ultra-violet, and by Abney and Festing for the infra-red region, have led to interesting results in relation to molecular chem-

istry. Thus Hartley finds that, in some of the more complicated aromatic compounds, definite absorption bands in the more refrangible region are only produced by substances in which three pairs of carbon atoms are doubly linked, as in the benzine ring, and thus the means of ascertaining this double linkage is given. The most remarkable results obtained by Abney and Festing show that the radical of an organic body is always represented by certain well-marked absorption bands, differing, however, in position, according as it is linked with hydrogen, a halogen, or with carbon, oxygen, or nitrogen. Indeed, these experimenters go so far as to say that it is highly probable that by this delicate mode of analysis the hypothetical position of any hydrogen which is replaced may be identified, thus pointing out a method of physical orientation of which, if confirmed by other observers, chemists will not be slow to avail themselves. The result, it is interesting to learn, has been rendered more than probable by the recent important researches of Perkin on the connection between the constitution and the optical properties of chemical compounds.

One of the noteworthy features of chemical progress is the interest taken by physicists in fundamental questions of our science. We all remember, in the first place, Sir William Thomson's interesting speculations, founded upon physical phenomena, respecting the probable size of the atom, viz., "that if a drop of water were magnified to the size of the earth, the constituent atoms would be larger than small shot, but smaller than cricket balls." Again, Helmholtz, in the Faraday lecture, delivered in 1881, discusses the relation of electricity and chemical energy, and points out that Faraday's law of electrolysis, and the modern theory of valency, are both expressions of the fact that, when the same quantity of electricity passes through an electrolyte, it always either sets free, or transfers to other combinations, the same number of units of affinity at both electrodes. Helmholtz further argues that, if we accept the Daltonian atomic hypothesis, we cannot avoid the conclusion that electricity, both positive and negative, is divided into elementary portions which behave like atoms of electricity. He also shows that these charges of atomic electricity are enormously large as compared, for example, with the attraction of gravitation between the same atoms; in the case of oxygen and hydrogen, 71,000 billion times larger.

A further subject of interest to chemists is the theory of the vortex-ring constitution of matter thrown out by Sir William Thomson, and lately worked out from a chemical point of view by J. J. Thomson, of Cambridge. He finds that if one such ring be supposed to constitute the most simple form of matter, say the monad hydrogen atom, then two such rings must, on coming into contact with nearly the same velocity, remain enchained together, constituting what we know as the molecule of free hydrogen. So, in like manner, systems containing two, three, and four such rings constitute the dyad, tryad, and tetrad atoms. How far this mathematical expression of chemical theory may prove consistent with fact remains to be seen.

Another branch of our science which has recently attracted much experimental attention is that of thermo-chemistry, a subject upon which in the future the foundation of dynamical chemistry must rest, and one which already proclaims the truth of the great principle of the conservation of energy in all cases of chemical as well as of physical change. But here, although the materials hitherto collected are of very considerable amount and value, the time has not yet arrived for expressing these results in general terms, and we must, therefore, be content to note progress in special lines and wait for the expansion into wider areas. Reference may, however, be properly made to one interesting observation of general significance. It is well known that, while, in most instances, the act of combination is accompanied by evolution of heat—that is, while the potential energy of most combining bodies is greater than that of most compounds—cases occur in which the reverse of this is true, and heat is absorbed in combination. In such cases the compound readily undergoes decomposition, frequently suddenly and with explosion. Acetylene and cyanogen seem to be exceptions to this rule, inasmuch as, while their component elements require to have energy added to them in order to enable them to combine, the compounds appear to be very stable bodies. Berthelot has explained this enigma by showing that, just as we may ignite a mass of dynamite without danger, while explosion takes place if we agitate the molecules by a detonator, so acetylene and cyanogen burn, as we know, quietly when ignited, but when their molecules are shaken by the detonation of even a minute quantity of fulminate, the constituents flew apart with explosive violence, carbon and hydrogen, or carbon and nitrogen, being set free, and the quantity of heat absorbed in the act of combination being suddenly liberated.

In conclusion, while far from proposing even to mention all the important steps by which our science has advanced since the year 1848, I cannot refrain from referring to two more. In the first place, to that discovery, more than foreshadowed by Faraday, of the liquefaction of the so-called permanent gases by Pictet and Cailletet; and secondly, to that of the laws of dissociation as investigated by Deville. The former, including Andrews' discovery of the critical point, indicates a connection, long unseen, between the liquid and the gaseous states of matter; the latter has opened out entirely fresh fields for research, and has given us new views concerning the stability of chemical compounds of great importance and interest.

Turning for a moment to another topic, we feel that, although science knows no nationalities, it is impossible for those who, like ourselves, exhibit strong national traits, to avoid asking whether we Anglo-Saxons hold our own, as compared with other nations, in the part we have played and and are playing in the development of our science. With regard to the past, the names of Boyle, Cavendish, Priestley, Dalton, Black, Davy, are sufficient guarantees that the English have, to say the least, occupied a position second to none in the early annals of chemistry. How has it been in the era that I have attempted to describe? What is the present position of English chemistry, and what its lookout for the future? In endeavoring to make this estimate, I would take the widest ground, including not only the efforts made to extend the boundaries of our science by new discovery, both in the theoretical and applied branches, but also those which have the no less important aims of spreading the knowledge of the subject among the people, and of establishing industries dependent on chemical principles, by which the human race is benefited. Taking this wide view, I think we may, without hesitation, affirm that the progress which chemistry has made through the energies of the Anglo-Saxon race is not less than that made by any other nation.

In so far as pure science is concerned, I have already given evidence of the not inconsiderable part which English chemists have played in the progress since 1848. We must, however, acknowledge that the number of original chemical papers now published in our language is much smaller than that appearing in the German tongue, and that the activity and devotion displayed in this direction by the heads of German laboratories may well be laid to heart by some of us in England; yet, on the other hand, it must be remembered that the circumstances of different countries are so different that it is by no means clear that we should follow the same lines. Indeed, our national characteristics forbid us to do so, and it may be that the bent of the Germanic lies in the assiduous collection of facts, while their subsequent elaboration and connection is the natural work of our own race.

As regards the publication of so-called original work by students, and speaking now only for myself as the director of an English chemical laboratory, I feel I am doing the best for the young men who, wishing to become either scientific or industrial chemists, are placed under my charge, in giving them as sound and extensive a foundation in the theory and practice of chemical science as their time and abilities will allow, rather than forcing them prematurely into the preparation of a new series of homologous compounds or the investigation of some special reaction, or of some possible new coloring matter, though such work might doubtless lead to publication. My aim has been to prepare a young man, by a careful and fairly complete general training, to fill with intelligence and success a post either as teacher or industrial chemist, rather than to turn out mere specialists, who, placed under other conditions than those to which they have been accustomed, are unable to get out of the narrow groove in which they have been trained. And this seems a reasonable course, for while the market for the pure specialist, as the color chemist for example, may easily be overstocked, the man of all-round intelligence will always find opportunity for the exercise of his powers. Far, however, from underrating the educational advantages of working at original subjects, I consider this sort of training to be of the highest and best kind, but only useful when founded upon a sound and general basis.

The difficulty which the English teacher of chemistry—and in this I may include Canada and the United States—has to contend against is that, while in Germany the value of this high and thorough training is generally admitted, in England a belief in its efficacy is as yet not generally entertained. "The Englishman," to quote from the recent Report of the Royal Commission on Technical Instruction, "is accustomed to seek for an immediate return, and has yet to learn that an extended and systematic education, up to and including the methods of original research, is now a necessary preliminary to the fullest development of industry, and it is to the gradual but sure growth of public opinion in this direction that we must look for the means of securing to this country in the future, as in the past, the highest position as an industrial nation."

If, in the second place, we consider the influence which Englishmen have exerted on the teaching of our science, we shall feel reason for satisfaction; many of our text-books are translated into every European language and largely used abroad, often to the exclusion of those written by Continental chemists.

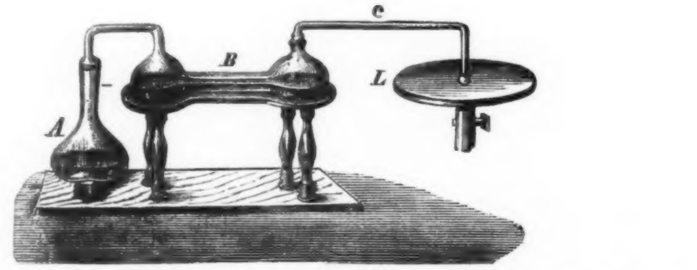
Again, science teaching, both practical and theoretical, in our elementary and many secondary schools, is certainly not inferior to that in schools of similar grade abroad, and the interest in and desire for scientific training is rapidly spreading throughout our working population, and is even now as great as, if not greater than, abroad. The universities and higher colleges are also moving to take their share of the work which has hitherto been far less completely done in our country than on the continent of Europe, especially in Germany, where the healthful spirit of competition, fostered by the numerous state-supported institutions, is much more common than with us, and, being of equal value in educational as in professional or commercial matters, has had its due effect.

Turning lastly to the practical applications of our science, in what departments does England not excel, and in which has she not made the most important new departures? Even in color chemistry, concerning which we have heard, with truth, much of German supremacy, we must remember that the industry is originally an English one, as the names of Perkin and of Maule, Simpson and Nicholson, testify; and if we have hitherto been beaten hollow in the development of this branch, signs are not wanting that this may not always be the case. But take any other branch of applied chemistry, the alkali trade for instance—what names but English, with the two great exceptions of Leblanc and Solvay, do we find in connection with real discoveries? In the application of chemistry to metallurgical processes, too, the names of Darby, Cort, Neilson, and Bell in iron, of Bessemer, Thomas, Gilchrist, and Snelus in steel, of Elkington, and Matthey in the noble metals, show that in these branches the discoveries which have revolutionized processes have been made by Englishmen; while Young, the father of paraffin, Spence the alum-maker, and Abel of gun-cotton fame, are some among many of our countrymen whose names may be honorably mentioned as having founded new chemical industries.

Hence, while there is much to stimulate us to action in the energy and zeal shown by our Continental brethren in the pursuit both of pure and applied chemistry, there is nothing to lead us to think that the chemistry of the English-speaking nations in the next fifty years will be less worthy than that of the past half-century of standing side by side with that of her friendly rivals elsewhere.

CONGELATION OF WATER BY MEANS OF SULPHURIC ACID.

A CONVENIENT and useful apparatus for the conversion of water into ice has been devised by K. Berberich, which consists of a flask, A, of about 15 cm. diameter, and two receptacles for sulphuric acid, each of which measures 10 cm. diametrically. The latter two are connected by a glass tubing 4 cm. wide and 15 cm. in length. The neck of the globe, B, to the left, is elongated, double bent, and closes hermetically the flask, A, while the bent tubing, C, is accurately ground into the globe, and sealed by means of sealing wax at the center of the metallic disk, L. On filling the globes to one-half of their capacity with concentrated sulphuric acid, and charging the flask partly with water, ebullition of the latter, after actuating the air pump, commences almost immediately, and is converted into ice within four or five minutes. The aqueous water rising from the water is avidiously absorbed by the acid in the first globe, causing a central depression of the surface of the liquid in the globe. When once charged with sulphuric acid, the apparatus can be used for four or five experiments.—*Annalen der Physik.*



APPARATUS FOR THE CONGELATION OF WATER BY MEANS OF SULPHURIC ACID.

AGAINST WROUGHT IRON FOR WATER PIPES.

To the Editor of the Scientific American:

Referring to your article on "Chemical Obstructions in Iron Water Pipes," I beg leave to say that some eighteen or twenty years since I laid down about 2,400 feet of "welded tube" or gas pipe of 1½ inches diameter, for the purpose of supplying my establishment with water—a neighbor of mine having used such pipe successfully for twenty-two years preceding, and it being still in good order at this time. For a year or two I had an abundant flow of water—7 gallons per minute or upward of 10,000 gallons in twenty-four hours—but after eighteen months the flow of water was sensibly diminished, and at the end of three years it had dwindled to a mere *trickle*. When I took up one of the pipes, I found it impossible to see through it or force a stick through it. Closer examination disclosed the fact that small nodules had been formed on the inner circumference of the pipe, which by gradual accretion from the oxide (or sesquioxide) of iron had grown (analogous to the formation of stalactites in caves) until the whole space was nearly filled up by *vertical* formations, and not longitudinal ones, as cited by Col. Ludlow. I had to resort to the slow and tedious process of working in and through a very small wire, which, by churning around, broke off some of these iron "stalactites." Then I introduced a larger wire, and so gradually cleared the pipe; but many of the "stalactites" were so large that in coming out they left a hole in the pipe, much of which was thus rendered worthless.

In striking contrast to these welded tubes was the condition of about 300 feet of *cast* iron pipes which had been in the same service for twenty years! Not a single nodule or stalactite had been formed in the *cast* iron in twenty years, while in about three years the *welded* tube was substantially filled with them!

I have from time to time submitted this remarkable difference to men experienced in the laying of water and gas pipes, but most of them declared themselves unable to solve the difficulty. A friend in Richmond, Virginia, suggested that in welding the tube it had become *decarbonized*, and hence (perhaps) its affinity for the oxide of iron, with which our water is frequently surcharged. Our soil is a deep red clay, its coloring matter being due (according to Prof. Rogers) to oxide of iron. Can you or some of your readers solve the problem?

B. JOHNSON BARBOUR.

Barboursville, Orange County, Va., Sept. 10, 1884.

DETERMINATION OF NITRIC ACID.

By M. ARNAUD.

CINCHONAMINE nitrate is almost insoluble in water acidified with from 10 to 15 per cent. of hydrochloric acid. It is therefore very easy to detect the nitrates qualitatively by bringing the solution to this condition. But for an exact determination it is impossible to employ this means, as, in drying, the acid becomes concentrated, and finally attacks not only the paper of the filter, but the cinchonamine nitrate itself.

After many attempts the author has succeeded in obtaining very good results by operating as follows:

The liquid containing the nitrates is neutralized with soda if acid, and with sulphuric acid if alkaline, the essential point being to obtain neutrality. The chlorine of the chlorides, if any are present, is eliminated with silver acetate, any excess of the latter being removed by the addition of a few drops of sodium phosphate. The filtrate is then evaporated almost to dryness and filtered anew if it is not absolutely clear, acidulated very slightly with a drop of dilute acetic acid. The liquid is then precipitated at a boil with a hot solution of cinchonamine sulphate. Cinchonamine nitrate falls down immediately in a crystalline state. It is let stand for twelve hours in a cool place. It is then brought upon a filter and washed with an aqueous solution of cinchonamine nitrate, saturated at the temperature of the atmosphere so as to remove any cinchonamine sulphate.

The object of this method of washing is to avoid dissolving any trace of the cinchonamine nitrate, however slight. Pure water, employed instead, would dissolve about 0·002 of its

weight of the cinchonamine nitrate. The precipitate is dried at 100° and weighed, being perfectly pure.

Cinchonamine nitrate has the formula:

$$C_{19}H_{24}N_2O,NO_3H.$$

Its high molecular weight is advantageous for the determination of nitric acid, as 359 parts cinchonamine nitrate represent 54 parts nitric acid, 101 potassium nitrate, or 82 parts calcium nitrate.

In this manner the author has determined the nitric acid contained in natural waters in the state of nitrates, probably as calcium nitrate, and has obtained at different times perfectly accordant results. For well waters he evaporates 1 liter of the sample to dryness, takes up the residue in alcohol at 40° per cent. and expels the alcohol by evaporation in the water bath. The aqueous solution resulting from this treatment contains all the nitrates as well as a certain quantity of chlorides. The analysis is continued as indicated above.

For determining the nitrates contained in plants the procedure is slightly modified. The plant is triturated and exhausted with boiling water. The liquid is evaporated to the consistence of an extract and redissolved in alcohol at 40 per cent. The alcohol is expelled by evaporation on the water bath, and in the liquid resulting the chlorides are eliminated by the addition of a small quantity of neutral lead acetate, any small excess of which is removed by means of a few drops of sodium sulphate. In the filtrate the nitrates are determined as above.—*Comptes Rendus; Chem. News.*

DISTILLATION UNDER ATMOSPHERIC PRESSURE.

ALL distillatory apparatus consist of two parts—one in which the heat is applied to the body to be distilled and vaporized, and the other into which the vapors that are formed enter in order to undergo the refrigeration that condenses them. The simplest of the respiratory apparatus used in laboratories (Fig. 1) consists of a retort into which is introduced the liquid to be distilled, and which is placed upon a furnace. The neck of this fits into that of a sphere whose opening must be wide enough to allow the orifice of the retort to reach the spherical part of the receiver. Finally, the sphere dips into a vessel full of cold water, and is cooled on its external surface by a wet cloth. The heated mixture begins to boil, and its vapors, escaping from the retort, cool and condense upon the cold sides of the spherical receiver. This latter serves at once as a refrigerator and a vessel for receiving the distilled product.

In the beginning, the empty receiver weighs less than the volume of water that it displaces, and tends to float. It is often kept in the water by placing a weight (a brick, for example) upon the top of its spherical part and upon the sides of the vessel containing the cold water. The want of stability of this much used arrangement makes it unrecommendable. It is preferable to make use of a sufficiently heavy ring of lead into which the neck of the receiver may be introduced, and which may rest upon the latter's bulge. Upon fixing a similar ring under the receiver, the latter will be prevented from turning laterally and even from getting broken. The water in the external vessel is renewed so as to keep it cold.

A simple arrangement of this kind is not adapted for materials that have a low boiling point, since a large proportion of the vapors escapes, and makes its exit through the neck of the receiver, which is kept hot by the vapors coming from the retort. The following, which is just about as simple, is a much more perfect arrangement.

The narrow part of the retort is fixed into the neck of a long, tubular receiver (Fig. 2) by means of a cork which it traverses. This annular cork exactly closes the space between the neck of the retort and that of the receiver. On another hand, in the tubulure of the receiver there is fixed, by means of a cork, perforated and arranged like the preceding, a long and narrow glass tube.

When the retort has been filled with the substance to be distilled, and placed upon a furnace covered with wire gauze, the receiver is immersed, as above stated, in cold water. The vapors that are formed become cooled in traversing the elongated neck of the receiver and are thoroughly condensed in the immersed part, provided the ebullition is not too rapid. In this latter case, the narrow tube, which presents the only open orifice, becomes heated, and indicates to the operator that the fire must be moderated.

The inconvenience of every apparatus of this kind is that the vapors which enter the receiver are not compelled to impinge against the sides, and may go directly to the exit-tube, or, in other words, the refrigeration is not methodical. Moreover, the refrigerating surface continues to diminish in measure as the receiver fills. Finally, if the receiver breaks, the entire distilled product comes in contact with the water. Despite these disadvantages, the rapidity with which such apparatus may be arranged causes them to be frequently employed.

The use of *refrigerators* permits of an exacter and more methodical condensation of the vapors. These are arranged as follows: The two orifices are placed in contact by means of a rubber tube, of from 3 to 4 cm. in length, into one end of which is introduced the neck of the retort, C (Fig. 3), and into the other the tube of the refrigerator. The latter being held in an inclined position by means of a clamp, a current of water traversing it from top to bottom, and a bent tube being adapted to its lower extremity, the free extremity of the bent one is fixed into the flask that is to collect the product. We may also suppress the central tube of the refrigerator in the flask, F, kept inclined. To facilitate this arrangement, the neck of the retort is cut at a point where it has the same external diameter as the tube of the refrigerator, and is then bordered with a lamp. Again, if the difference between the diameters is considerable, we may, by means of a lamp, draw out slightly the one of the two tubes that is the larger, and cut it at the proper point to obtain an equality in the diameters. Finally, we may solder to the extremity of the refrigerator a cylindrical tube, 2 or 3 cm. in diameter and 6 or 7 in length, into which is fitted the neck of the retort previously provided with a cork. This latter contains an aperture running in the direction of its axis, and the whole is arranged so as to form a tight joint.

When the substance distilled attacks cork and rubber, the neck of the retort is drawn out to a sufficient length to allow the tube that terminates it to enter the refrigerator to some depth. The rubber with which the two parts of the apparatus are connected is thus nearly out of the range of the vapors.

It is very evident that the retort may be replaced, and advantageously too, in many cases, by any other spherical vessel with a narrow neck. In this case the receiver is closed (Fig. 4) by a cork or rubber stopper containing an aperture that is traversed, through slight friction, by a glass tube. This latter is so bent that the angle formed by its two branches shall correspond to the inclination that is given to the refrigerator. The external extremity of the tube is connected with the refrigerator by means of one of the arrangements described above for the neck of the retort. As for the internal extremity, it is well, especially if the tube is narrow, to bevel it off so as to facilitate the flow, drop by drop, of the condensed liquid which accumulates therein, and which, without such a precaution, might be carried along by the vapor toward the refrigerator.

Moreover, in the case of a liquid that would attack the joints, the bent tube that fits into the neck of the receiver may be that of the refrigerator itself.—*Science et Nature.*

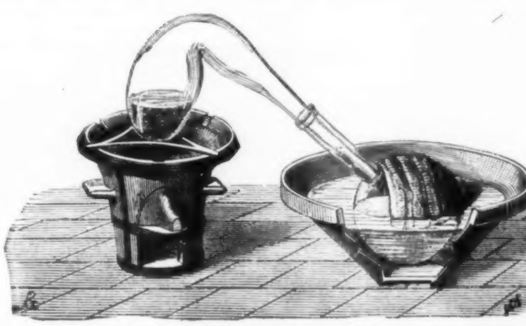


FIG. 1.

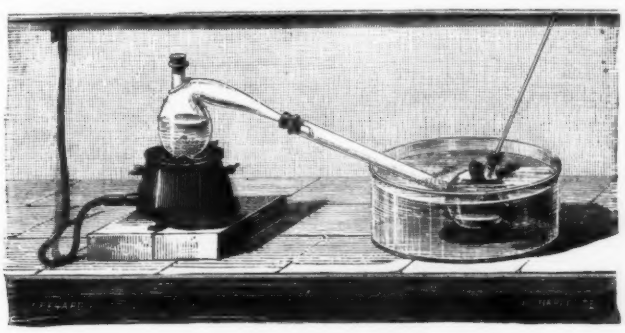


FIG. 2.

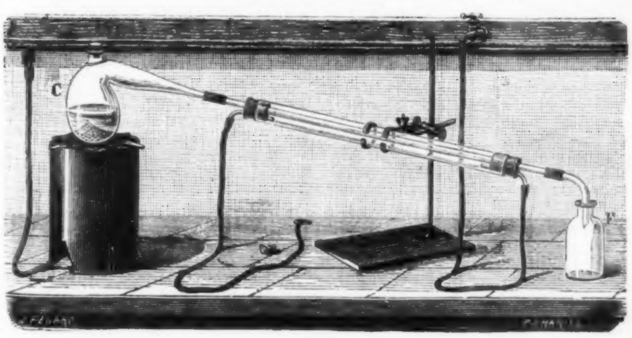


FIG. 3.

FIG. 4.

DIFFERENT FORMS OF DISTILLING APPARATUS.

HOW SHOULD A HORSE BE SHOD?

SECRETARY RUSSELL, of the Massachusetts State Board of Agriculture, recently delivered an address in which he spoke chiefly on the subject of preserving the hoofs of horses. In olden times, he said, the Romans did not use the horse for a draught animal to the extent he is now used. Another reason why barefooted horses were possible is that the ancients of history occupied no part of the earth where the ground for a quarter of the year was frozen or covered with solid ice. Horse shoeing originated with the nations of the North, and was probably first devised by the German races where the earth was hard, rugged, frozen, or covered with ice much of the time. We shall find that economy in the use of the horse is the underlying reason for horse shoeing. Doubtless the horses of Rome suffered extremely at times for want of shoeing. A Roman gem in a Paris museum shows that the Roman soldiers carried leather buskins to slip on when the horse's foot was worn off. The Japanese use plaited straw on the hoofs of their ponies, and under such protection the hoof soon restores itself. They had generations of horses that were never shod, and we make a mistake in comparing our horses with theirs. A distinguished naturalist, on this platform, recently showed that he had overlooked this matter of heredity. Here we are, the inheritors of a thousand years of defects of the feet and weaknesses of the hoof from disuse. If he had said, begin now and in a few hundred years you may have horses that need no shoes, he would have been nearer the fact. Xenophon must have been aware that even with the system in use in his day all horses' feet were not sound, else why did he tell the buyer to look to the hoof?

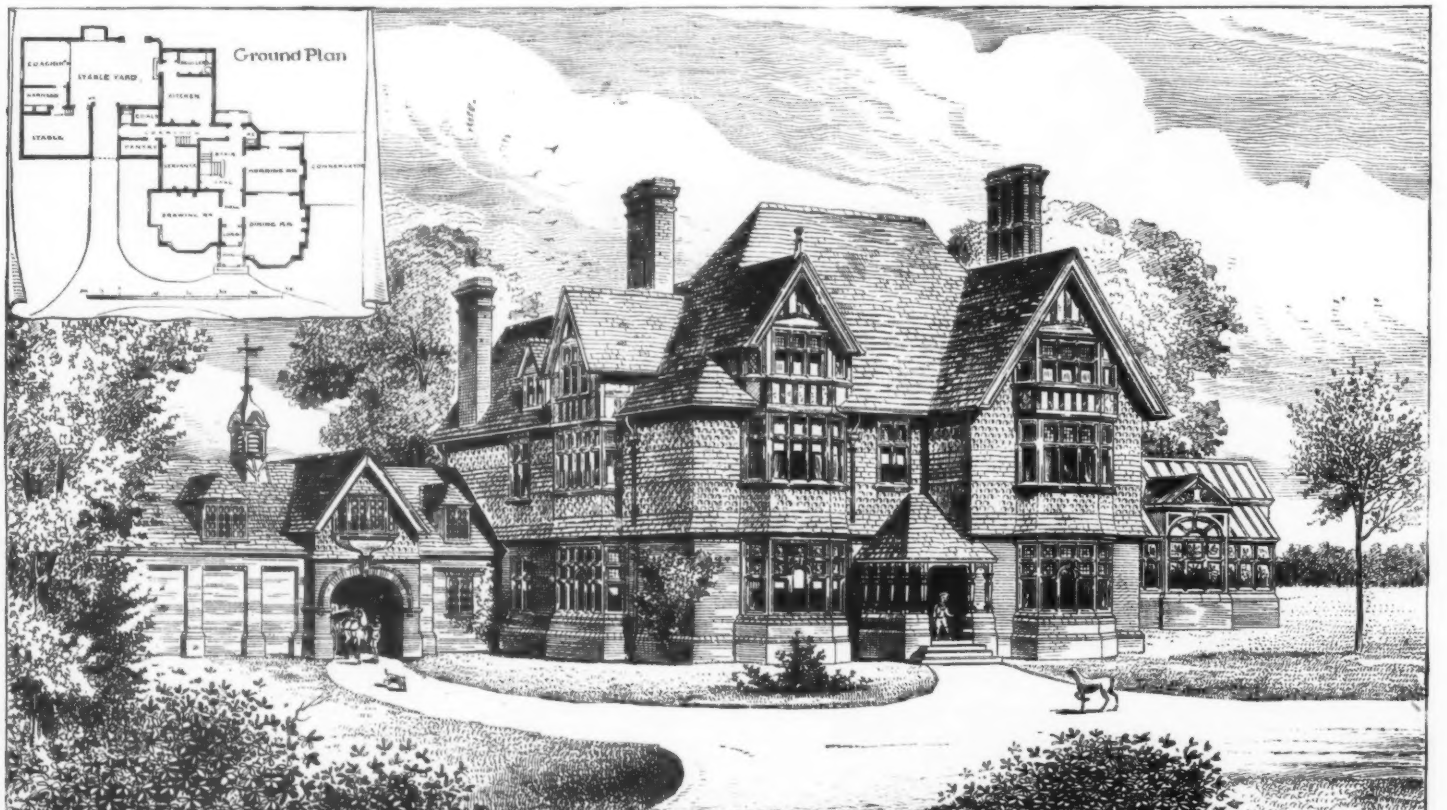
In 1858, Mr. Russell was called to reside in a tropical country for five years, and there it was the universal custom to use horses that had never been shod. These horses, however, were not used for draught. He discovered that it was unnecessary to shoe saddle horses, and that the various common hoof diseases known here were there entirely unknown. He declared as the result of his study that the horse if properly shod would stand upon the frog. In explaining his reasons for this belief, Mr. Russell said: "The hoof is a horn box in which the true foot rests. The hoof grows out of the coronary band, which is located just where the hair and the hoof meet; the foot has a single finger, and the hoof is the finger nail; its lower part has no use but to be worn away, and it is continually renewed. The band at the back side of the hoof is continued downward, and forms the frog, which rests between the two sides of the heel." He condemned the usual shoeing with toe and heel calks, in that the latter takes the frog out of action entirely. Action and motion are the law of life, and an inactive frog soon becomes hard, lifeless, useless. He objected to Professor Wood's exhibition of horse shoes, and said it was a slander on American farriers. The English rarely use the toe calk, and the result is that the rear of the hoof is raised too high, changing the line of support and bringing a great and unnatural leverage upon the joint. It is no wonder that London is called the "hell of horses," and that the London Omnibus Company buys its horses at five years old and sells them, used up, at eight or nine. Our own use of the heel and toe calk is bad, but not so bad as the use of the heel calk alone. The result of heel calks, he said, is known as "corns," but it is a misnomer. It is a common and very annoying disease. Another result of such shoeing is the contraction of the hoof. The farrier advises more iron. Iron caused it, and he increases the weight; then comes a leather pad, which shuts off the natural perspiration of the foot, and then tar is used, but none of them broaden the "wired in" heel. He was very severe in denouncing the "bar" shoe as cruel. It is put on to get a bearing on the frog. It works well temporarily, but it must be used continuously, and the result is that it presses the frog upward and produces the inflammation known as the navicular disease. Again, as the heel is drawn in, quarter and toe cracks follow; the foot begins to be "full jeweled." Inflammation goes on, then laminitis, then softening and dropped sole, requiring more iron, more leather, more tow, and more tar.

It is easy to point out the trouble, but he also felt sure he could suggest a remedy. He spoke of horses of his own and others, racers, who for generations have never been shod, except temporarily, but their feet will wear with continuous draught. He said Marshal Bazaine told him in Spain, seven years ago, that Napoleon would have escaped from Russia with his army in safety but for the failure of his supply of "roughened" or "sharpened" horse shoes. His horses, being without shoes, broke down on the roads, and disaster resulted. He believed the secret of success in horse shoeing is to follow the French and Spanish method, which is never to calk a shoe on the front, except for use on the ice. And the calk should be removed as soon as possible. The proper shoe is as light as possible. Soft iron should always be used, for steel is too slippery. He would put the strength of the shoe in the outer rim, and use as few nails as possible. The hoof is elastic, and the use of an unyielding rim of iron prevents this action. For this reason, the unilateral method of shoeing—the nails only one side—is desirable, if a light shoe is used. He would have a horse shod every month, and three weeks is better.

NATURE'S oxidizers, peroxide of hydrogen and ozone, are suggested as possible bleaching agents of the future. Peroxide of hydrogen differs from water in composition only in having twice as much oxygen, with half of which it parts readily and becomes water. Ozone, the natural purifier of the air, is probably the most powerful oxidizing agent known and has remarkable bleaching power. The expense of obtaining these substances now prevents their extensive use for bleaching purposes.

SUMMER COTTAGE, TUNBRIDGE WELLS.

THIS house is being erected as a summer residence at Sandown Park, Tunbridge Wells. The contractor is Mr. D. Baker, of Folkestone; the architect, Mr. Reginald Pope, of Folkestone.



A·Summer·Cottage·for·Walter·Clement·Esqre·Tunbridge·Wells·Kent· REGINALD POPE. ARCHITECT, FOLKESTONE

Photo Lithographed & Printed by James Akerman, 6 Queen Square, W.C.

THE SUPERGA RAILWAY.

THE new railway to the Superga from Turin, opened to the public a few months since, cannot fail to be regarded by all engineers with great interest. To the general public it has already proved a great attraction, and few visitors to the Exhibition leave Turin without having made a pilgrimage to the Superga by the "Ferrovia Funicolare."

The Church of the Superga was built in fulfillment of a vow made to the Virgin by the Duke Vittorio Amedeo II. of Savoy at the siege of Turin in 1706, and having gained the victory over the French its construction was decreed, and it was built from designs of the celebrated architect Juvara. The crypts contain the tombs of the princes of the house of Savoy. The church is built on a hill about five miles to the east of Turin, at a height of 678 meters above the level of the sea.

The railway to the Superga cannot be regarded as a mere cable line, where the rope has to be of sufficient strength to haul the dead weight of the cars and their freights up hill, as is the case with the Vesuvius funicular railway, the Highgate steep gradient tramway (recently opened), or with the various wire rope railways that are being worked in America and elsewhere. This line, on the other hand, is the first practical application of a system invented by an Italian engineer, Signor Tommaso Agudio, by which the power of a fixed engine is transmitted to the mechanism of a driving-car or "locomotore" by means of an endless steel rope running at a high speed, and in the present case five times as fast as the train. In this way a far lighter rope can be used than would be the case were the trains merely hauled up. The first experiments of this system were made by Signor Agudio as far back as 1863 and 1864, on the incline of Dusino on the line between Turin and Alexandria, and afterward on the French side of the Mont Cenis near Lanslebourg in 1874 and 1875; and notwithstanding the favorable results obtained, no further application of the system was made until the present time. On the experimental line just mentioned, an incline of 38 to 100 (1 in 2·53), and 1,300 meters in length (over three-quarters of a mile), was successfully worked.

Finally, in March, 1883, a concession was granted by the Italian Government to the municipality of Turin for the construction and working of a cable line, on the Agudio system, from the hamlet of Sassi at the foot of the hill to the Superga, together with a subvention of 900,000 Italian lire (£36,000), which concession was transferred to a limited liability company formed in Turin, who, in addition to the Government subvention of 900,000 lire, will receive from the city of Turin a further subsidy of 300,000 lire (£12,000), and, among other conditions, the municipality, after a certain number of years, are to have a share in the receipts from the working of the line.

The principal feature in this system of railway is a steel wire rope, which is made endless by careful splicing, this rope being driven at a high speed by a stationary engine.

The endless rope in the present case passes from the Sassi terminus, situated at the foot of the hill, and about three miles by steam tramway from the Piazza Castello (which is the center of the tramway system of Turin), and up the hill to the Superga station, where it passes over a large terminal pulley 4 meters in diameter (13 ft. 4 in.). At the lower or Sassi end the rope passes round the driving pulley fixed on the main shaft of the engine, suitable apparatus for its proper tension being provided, which will be described afterward.

The lower portion of the loop of endless rope, which is driven in an upward direction by the engine, is supported in its passage up hill by a sufficient number of grooved pulleys fixed at about the level of the rails to keep it from touching the ground, and at a distance of 52 centimeters (21 ft.) outside the left-hand rail of the track; on curves guiding pulleys are used, and are placed horizontally, and instead of a groove have a flange on their lower side; the bearings being constructed in such a way as to protect the axles from dust and rain.

The upper portion of the loop, or down line, is carried at a height of about 4 meters above the level of the rails by 35 grooved pulleys, of which 15, 2·30 millimeters in diameter (7 ft. 8 in.), are placed with vertical or slightly inclined axes, in order to guide the rope round curves, while the remaining 20, which are 1 meter (3 ft. 3 in.) in diameter, serve to support the rope on the straight parts of the line. As only the lower part of the loop of endless rope is used for driving the trams, the return, or upper part, no longer requires to be carried parallel to the line of rails, and the 35 supporting pulleys, which are securely carried on brick pillars, are placed where it has been found most convenient, sometimes on the right and sometimes on the left hand side of the track.

The slack in the rope is taken up by a gravitation car to which the terminal pulley at the lower end of the line is fixed, the car being held back against the pull of the rope by a counter weight. The weight now used is 1,300 kilogrammes (26 cwt.). The length of ways upon which the car travels is about 15 meters, and while the rope is running it is in constant oscillation, moving irregularly through a space of about $1\frac{1}{2}$ meters (4 ft. 10 in.). The down hill or upper portion of the loop passes over this pulley, which is 4 meters in diameter (13 ft. 4 in.), and from thence, at the level of the ground, round another pulley of similar diameter fixed at about 20 yards further up the line than the driving pulley (which is placed in the middle), back over this, making two turns over these two pulleys before proceeding on its journey uphill, the object of the additional pulley being to prevent the slipping of the rope on the driving pulley, as would be the case were it in contact with only a small portion of the circumference, instead of being so with the whole. The second pulley is fixed upon a slide carriage, which, by means of screws, can be adjusted so as to take up any permanent lengthening of the rope. The driving pulley is also 4 meters (13 ft. 4 in.) in diameter, and has several grooves, in case an extra turn of the rope should be found necessary.

The cable is 22 millimeters ($\frac{13}{16}$ in.) in diameter, composed of six strands each of eight wires of crucible steel, 2 millimeters ($\frac{1}{12}$ in.) diameter, would round a hemp core. The breaking strain is given at 135 kilogrammes per square meter, or about $85\frac{3}{4}$ tons per square mile, but the actual strain upon the rope does not exceed 25 kilogrammes per square millimeter, or $15\frac{7}{8}$ tons per square mile. The weight of the rope is $1\frac{1}{3}$ kilogrammes per meter run (about 1 lb. per foot).

The stationary engine was constructed by Messrs. Sulzer, of Winterthur, and is of 300 nominal horse-power. It consists of two horizontal cylinders, the valve gear being on a plan introduced by the firm; the engines can be worked with or without the condenser. Steam is supplied from four boilers of the Cornish type.

The terminus at Sassi being 223 meters above the level of the sea, while that of the Superga is 642 meters, the difference of level between the two extremities of the line is 419 meters, and its length being 3,150 meters (or about 2,000 meters less than the old carriage road), the mean gradient is 13·30 per 100 (1 in 7·51). The minimum gradient is 7 per 100 (1 in 14·30), while the maximum gradient is 20 in 100, or 1 in 5. The minimum radius of the curves is 300 meters.

The line is of the ordinary 4 ft. $8\frac{1}{2}$ in. gauge, in order that the cars may be used on the steam tramway to Turin.

The rails are of the Vignoles type, weighing 18 kilogrammes per meter (36 lb. per yard), and are fixed upon longitudinal sleepers, which are connected by cross sleepers of iron, to which is firmly bolted another longitudinal sleeper which carries a double rack with teeth placed vertically, into which the pinions of the driving car work.

In order to secure the permanent way from slipping, two piles, $1\frac{1}{2}$ meters in length, are driven on the lower side of each cross sleeper.

The width of the line at formation level is 4·20 meters (14 ft.), while that of the tunnels is 4·50 meters (15 ft.). The first tunnel is 67 meters in length, and situated at 783 meters from the lower terminus; while the second is 61 meters long, and at 1,799 meters from the same place.

The central rack is formed of a bar of steel 11 centimeters ($4\frac{3}{8}$ in.) in depth by 12 millimeters ($\frac{1}{2}$ in.) thick, bent in such a way as to form a double row of teeth, in which the pinions carried on the lower ends of the vertical shafts of the "locomotore," or driving-car, can work. This driving-car, or "Locomotore Agudio," which is the most important feature in this system, consists of a metallic frame-work supported by four wheels which run on the rails, and which are completely independent of the mechanism of the "locomotore" which they carry.

The frame carries two horizontal axles; at the left hand end of each (looking up the line) are fixed a grooved pulley 2·30 meters in diameter (7 ft. 8 in.). The driving cable passing under the front pulley and over it to the hind one, and back underneath again, sets them in motion, transmitting its speed to them, which is converted into power by the mechanism. This hind axle carries near each end a bevel wheel, which can be thrown in and out of gear by a friction clutch. These wheels gear into other bevel wheels fixed at the uppermost end of two vertical shafts, one on each side of the central rack, and carry at their lower ends the pinions which gear into it.

It will be readily seen that while the rope is running, the driving pulleys on the horizontal shaft will transmit their motion by means of the bevel gearing to the pinions working in the rack, and that the speed of the car, as compared with that of the rope, will depend upon the ratio between the diameter of the driving pulley on the "locomotore," which is the receiver of motion, and the pinion, and which in the present case is as 5 to 1. The bevel wheels have 28 teeth, and the pinions 23.

The front axle, on the other hand, carries the two bevel wheels near the center, so that, when in gear with the horizontal ones on the vertical axles, a reversed motion is given to the car, while the cable is constantly running in the same direction. Thus the train can be stopped by throwing both sets of bevel wheels out of gear, driven uphill by throwing the hind bevel wheels into gear, reversed by throwing these out of gear and putting into gear the front pair. This is only used for backing the train at the stations and for starting it, as the downhill journey is accomplished by gravitation, when both sets of bevel gearing are disconnected, and the speed of the train is controlled by the brakes.

The right ends of the horizontal axles also carry pulleys over which a brake strap passes, the tightening up of which serves to check the speed going down hill and for pulling up the train when going slowly. The most powerful brakes, however, are those which act upon the hind vertical axles, and consist of wooden blocks which, by means of suitable screw gearing, can be brought to bear upon a cylindrical projection cast upon the lower side of the horizontal bevel wheels. The blocks wear rapidly, but can be easily replaced.

As a further precaution, a means of gripping the central longitudinal sleeper is provided, consisting of a pair of jaws which can be tightened up by a screw, and this takes a tight hold of the sleeper and effectually stops the train.

In going up hill, four pawls—a pair on each side of the central rack—are brought into play, and in the case of the

breaking of the rope, would act as a ratchet, and stop its running down hill.

The train at present is composed of two carriages, capable of containing 60 persons each; and the "locomotore," both for ascent and descent, is always on the downhill side of the train.

The carriages are not only provided with powerful brakes, which not only act upon the wheels, but also with a means of gripping the central sleeper, as is the case with the "locomotore."

Communication between the conductors of the train is constantly kept up with the driver of the stationary engine by a simple system of telegraphy, so that it is possible for those in charge of the train to give instructions to increase or slacken speed, or to stop the rope at any moment. Between Turin and Sassi the carriages of the Superga Railway are drawn by the locomotives of the Turin and Gassino Steam Tramway, which is laid on the provincial road, the railway being connected with it by means of a siding, and in this way passengers from Turin have not to change carriages.

The arrangement of the points and crossings is highly ingenious, a portion of the central sleeper with rack being lowered into a trench by means of cams, in order to allow the wheels of the carriage to pass from one line to the other.

The contractors for the construction of the line were Messrs. Delvecchino and Perini, and great credit is given to Mr. E. Perini, the representative of the firm, for the manner in which he has worked out all the details, and overcome a host of difficulties which could not fail to have arisen in an undertaking of this nature.

The greater part of the material for the construction and working of this line was made in Italy, the railway plant works of Savigliana supplying the central rack, metallic sleepers, girders for bridges, etc., the carriages and trucks. The two "locomotori" were made at the workshops of the Alta Italia Railway, with the exception of certain portions of special mechanism which were executed by the Royal Arsenal of Turin, and by Messrs. Enrico, engineers. The pulleys, bearings, etc., were supplied by the foundry of Messrs. Colla.

The number of persons employed for working this line are 44, composed as follows: 1 engineer and traffic manager, 2 station masters, 2 ticket clerks, 2 guards, 2 brakesmen, 3 drivers and 2 assistant drivers for "locomotori," 2 engineers, and 2 stokers for stationary engine, 1 oiler and linesman, 2 pointsmen, 1 head platelayer with 4 assistants, 1 ganger, and ten laborers for maintenance of line.

No experiments have yet been made as to the cost of working, consumption of fuel, etc.

It is evident, however, that the Agudio system is especially adapted for very mountainous countries, where the gradients for a locomotive line would be too heavy, and where abundant water power might be availed of for motive power.—*Journal of the Society of Arts.*

IMPROVED MASONRY CRANE.

THE recent visit of the Prince of Wales to Newcastle, and the successful opening of the Albert Edward Dock at Coble Dene, has attracted a great deal of attention to the extensive improvements which the Tyne Commissioners have effected on their river, and to the large works which are still in progress there. Of primary importance among these works are the two great piers which run far out to sea on the north and south sides of the river mouth. These piers are mainly composed of concrete blocks placed and bonded with concrete hearting, and when it is understood that a large proportion of these blocks weigh about 40 tons, the block-setting plant used to put them in position becomes of considerable interest; for long after the commencement of the work the blocks were set by overhead travelers running on staging supported by piles, and this method of construction is for the present still in use on the south pier.

On the north pier, the staging and traveler method of setting has been superseded for some time by the more modern plan of using a "block-setting machine," and Mr. Messent, the engineer to the Commissioners, must be congratulated on having designed and set to work the largest "block-setter" in existence, a machine that has rightly earned its title of "Mammoth," and we think that our readers will be much interested in the engraving and description of this machine that we give on this page.

The main structure of the Mammoth, including the under carriage, girders, jib, bracing, and truss work, were made in the Tyne Commissioners' own yard and workshops. The whole of the machinery, engines, boiler gearing, and traveling carriage, and also the great revolving turntable, were constructed under Mr. Messent's superintendence by Messrs. Stothert and Pitt, of Bath, who for many years have made block setting and harbor-making plant a specialty. The radius of the Mammoth is 92 feet and the load 40 tons to 45 tons; we believe that this is by far the longest radius that has been used with a traveling crane intended to lift such heavy loads. The engraving is taken from a photograph of the machine in actual work, and shows clearly the general design.

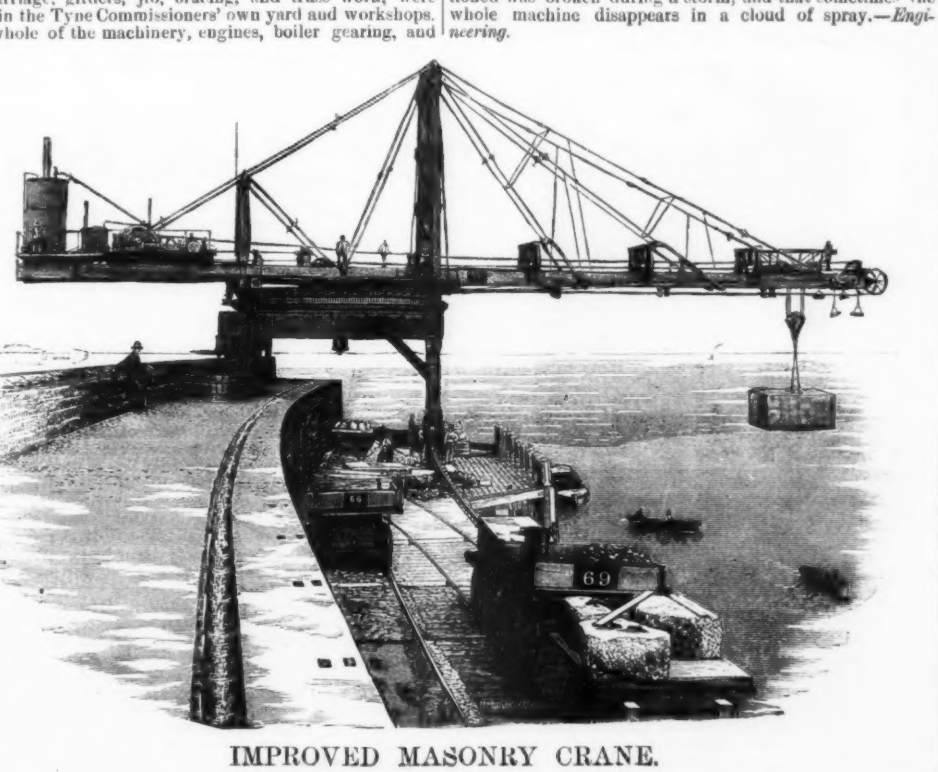
The machine travels on two rails, one laid on the inside edge of the pier, and the other on the outside parapet; on the under carriage a system of heavy girders is placed to carry the large circular roller path, on which the whole of the superstructure revolves. This roller path is 34 ft. in diameter, and on it runs a ring of fifty-two live rollers. The circular movement is produced by a pinion gearing into the large spur ring seen in the engraving.

The whole of the motions are worked by steam, viz., the lifting, slewing, and racking in and out from the maximum radius of 92 ft. to the minimum radius of 20 ft.

For block-setting, great accuracy and steadiness of motions are essential, especially in lowering the blocks into place; the Mammoth was therefore fitted with the patent hydraulic brakes of Mr. W. Matthews; these brakes act by compressing water in cylinders in front of pistons, an arrangement being provided by which the escape can be adjusted with extreme nicety, and the descent of the heaviest loads regulated with the greatest accuracy; the hydraulic brakes have been exclusively applied for block-setting machines, and have worked exceedingly well in practice.

The Mammoth, when in complete working trim, weighs with load about 300 tons, but the weights are so well balanced that, when the machine is being slewed at a good speed, the motion is almost imperceptible, and the Mammoth can be handled as quickly or easily, and much more quietly, than an ordinary steam crane.

The large brackets shown on the jib carry an ingenious arrangement of chain porters which are opened by the frame seen on the traveling carriage. The large side timbers used for stiffening the jib beams are of interest, from the splendid pieces of Vancouver pine used in their construction; we believe that timbers were procured of the unusual scantlings of 2·8 ft. by 2·8 ft. by 98 ft. long. It will give some notion of the force of the sea at Tynemouth when we say that one of the large brackets previously mentioned was broken during a storm, and that sometimes the whole machine disappears in a cloud of spray.—*Engineering.*

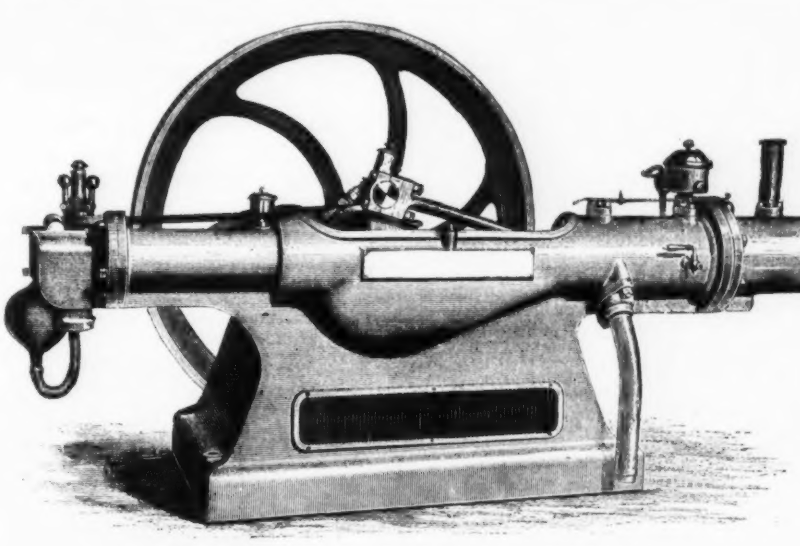


IMPROVED MASONRY CRANE.

THE "STOCKPORT" GAS ENGINE.

A NOVEL form of gas engine is now made by J. E. H. Andrews & Co., of Stockport, manufacturers of the well-known Bisschop gas engine.

The Stockport gas engine is of the type of those which compress the charge, and it has an explosion at every revolution, whether the engine be lightly or heavily loaded. As will be seen from the illustration, there are two cylinders arranged on the same axial line, one serving to draw in the combustible mixture of gas and air, and the other acting as the working cylinder in which the charge is exploded to produce power. The pistons of these two cylinders are connected by a trunk, so that they are in rigid union, moving simultaneously in the same direction. The central part of this trunk, in the free space between the two cylinders, is partly cut away, so that for a portion of its length it is no longer cylindrical, but is rather less than half a cylinder. This is for the purpose of accommodating the connecting rod, which is pivoted at one end to a pin in the center of the trunk, and at the other end to the crank-pin, which works in the reduced portion of the trunk. The whole arrangement recalls some form of steam pumps, with the crank-shaft midway between the steam and water cylinders.



THE STOCKPORT GAS ENGINE.

The cycle of operations, to use a phrase which became stereotyped in the trial of Otto *v.* Linford, comprises one revolution only, and is very easy to follow. Commencing with the explosion, the working piston is driven forward by the force of the expanding gases, which follow it almost to the termination of its stroke. Just before it reaches the end, however, it passes an open exhaust port, communicating through a pipe with the outer air. At this point the gases have, in the normal conditions of working, a pressure of about 30 lb. per square inch, and they instantly discharge themselves until the cylinder and combustion chamber are filled only with products of combustion at atmospheric pressure. At this moment the slide valve opens communication between the cylinder and a reservior (to be described later), filled with combustible mixture under moderate pressure. This sweeps out whatever remains of the exploded charge, driving it before it, without sensibly mixing with it, and completely filling the cylinder before the piston, which has now commenced its return stroke, covers the port. All this occupies but a very slight portion of the piston's stroke, but as it travels very slowly for a considerable angle of the crank on each side of the center, there is ample time for the evacuation of the spent charge and the introduction of the new one. The piston now moves inward, driven by the energy in the flywheel, and compresses the mixture into the combustion chamber at the end of the cylinder, until the crank again passes the center, when the ignition port is opened, and the cycle is complete.

Turning now to the other or supply cylinder, and commencing at the same point, namely at the moment when the explosion occurs, we find the cylinder filled with an intimate mixture of gas and air. These two fluids are intentionally blended as completely as possible, stratification or the introduction of air cushions being purposely avoided, as the thorough ventilation of the working cylinder at each revolution keeps the temperature of the metal and the residual gases below the point at which they will ignite the incoming charge. As the piston moves backward it forces the mixture into a reservoir in the bedplate of the engine, when it is momentarily retained, and then on its outward stroke it draws in a fresh supply. Thus it will be seen that when the working piston is propelled by an explosion, the supply piston forces a charge into the reservoir ready to sweep out the products of combustion, and to take its place ready for compression, and when the working piston is compressing this charge, the supply cylinder is being filled afresh.

As there is an explosion at every revolution, it follows that the strength of the charge must be varied to suit the load on the engine. This is done by a governor which controls a small equilibrium valve in the gas passage, raising and lowering it as the speed increases and decreases. There is, however, a limit beyond which this method of regulation cannot be carried, for if the mixture be made too poor it will not ignite. If an engine were running absolutely empty, it might easily happen that the poorest ignitible mixture would provide too much power, and the result would be an excess of speed. To prevent this the governor, besides controlling the throttle valve, determines the position of a stud on a lever connected with a valve on the cylinder. At a given speed the stud is moved into the path of a tappet, and opens the valve when the compression is taking place in the working cylinder. The result of this is that a part of the charge is driven out of the cylinder through a pipe which ends in the air inlet pipe to the supply cylinder, from which the rejected charge is drawn at the next stroke, and delivered again to the reservoir.

Besides the above-mentioned tappet valve, which is usually out of action, there are only two valves in the engine,

both of them slide valves, and both operated from the same eccentric. The working cylinder valve is driven direct, as in a steam engine. The supply cylinder valve is worked by an arm at the end of a small weighshaft, the other end of which carries a slotted lever gearing with a pin projecting from the strap of the eccentric. This pin follows a curved path, moving backward and forward in the slot, the result being that the angular velocity of the lever, and consequently the speed of travel of the valve, varies very greatly at different parts of the stroke. The valve of the supply cylinder is a flat plate working between the face on the cylinder and a back plate, in which there is a cavity in constant communication with the gas-pipe, after it has passed the throttle valve. There are three ports in the cylinder face, one opening into the air, one to the cylinder, and one to the reservoir, and there is a cavity in the face of the valve, with a number of small passages leading from it to meet the cavity in the back plate. During the indrawing stroke the gas enters the valve in fine streams, and the air sweeps across it at right angles as it is drawn to the inlet port of the cylinder. At the end of the stroke the movement of the valve cuts off the gas and air, and puts the cylinder port in communication with the pipe leading to the reservoir. The whole arrangement is exceedingly simple, and resembles the valve of a single-acting steam engine.

The valve of the working cylinder is likewise a flat plate valve. It slides on the side of the cylinder, not the end, just in the same way as the valve of a steam engine. Its function is to put the cylinder in communication with the reservoir when the piston passes the exhaust port, and to break the communication when the piston again closes the port. In addition to this very simple operation it has to effect the ignition of the charge. The master light burns in a recess or chimney formed in the end of the cylinder, or more correctly in the combustion chamber. It has an opening through the valve face, and past this opening there travels a cavity in the valve. This is supplied by gas, which becomes ignited, and in this condition is carried to the main port of the cylinder, the whole width of the cavity being presented to the port at once, and thus insuring the certainty of an explosion. The valve is cored out for the circulation of water, which enters and leaves through flexible connections, and by this means its temperature is kept at a point where there is little fear of seizing or cutting. It is held up to its place by a back plate with springs under the nuts which secure it, and is further retained by clamps on the studs. These give way as the valve expands, and allow it to obtain just the amount of room which it requires.

The gas consumption of these engines is 35 cubic feet per hour per actual horse-power, or 20 ft. per indicated horse-power when working at their full capacity. The average pressure in the cylinder is 73·69 lb. per square inch, the initial and terminal pressures being 210 lb. and 30 lb. The motion is regular, since there is an explosion at each revolution, whether the load be light or heavy, and a sudden increase of work cannot stop the engine.—*Engineering.*

A NEW TACHOMETER.

UNDER the name of tachometer, or revolution counter, is designated an apparatus which is generally designed for registering the number of revolutions that a steam engine or an electric machine makes within a certain period of time—usually sixty seconds.

Electricians, who by the nature of their profession are called upon to look after the putting in of electric lights, more particularly have need to know the actual speed of the machines. The irregular running of the latter is always shown by variations in the light, which are less sensible perhaps with arc lamps, but very clearly marked with incandescent ones. It must be added that in this last-named kind of lamps, scintillation, which is so fatiguing to the sight, is still more pronounced when the joint of the belt passes over the pulley of the electric machine's shaft, especially if the speed of the latter reaches 1,200 or 1,800 revolutions per minute. On another hand, when one is obliged to have recourse to motors supplied by independent boilers, the irregularity in the running of electric machines becomes very perceptible. The different pressures, which are difficult to overcome in boilers, are clearly shown by a variation in the velocity of the electric machine and by a want of steadiness in the light of the lamps.

It is indispensable, therefore, in practice, to verify the speed of the machines from time to time, although such verification presents some difficulty with the counters that the industries now have at their disposal. These require, in fact, very close attention and certain precautions on the part of the operator. The use of a seconds watch, whose running is often influenced by proximity to the electric machine, gives inaccurate indications, and the result is that it becomes necessary to take a mean of the velocity after calculations that are relatively long, and difficult to exact from the workmen in charge.

Up to the present time the most widely used tachometer has been Deschiens's, which is shown in Fig. 1, and which is so well known that we need not describe it. It is a strong, simple apparatus that, although of small size, elegantly solves a pretty complicated problem in mechanics. But it nevertheless has the inconveniences that we have noted above, and we have had occasion to find out, under many circumstances, that it requires a certain amount of patience, especially when the experiments, or, better, the verifications, have to be made during night, upon a certain number of machines.

It became necessary, then, to find an apparatus that should be capable of instantaneously showing the variations in speed and the number of revolutions of the shaft without the obligation of having recourse to a seconds watch and to an aid subject to error or distraction. An English engineer, Mr. Young, has solved this problem in a very ingenious way by using the principle of the centrifugal governors of steam engines. Figs. 2 and 3 give an external and internal view of this little apparatus, whose mechanism is inclosed in a cylindrical, nickelized copper box 8 cm. in length by 6 in diameter. It consists of a needle, A, movable upon a dial, C, divided concentrically into two parts. The smaller circle comprises the figures from 100 to 500, divided into fifties, and subdivided into fives, and the larger one permits of reading velocities of from 400 to 2,000 revolutions, with an intermediate division of twenty-fives between each 100.

Upon one of the two axles, B B', which project from the box, there is fixed a triangular point of highly tempered steel, which is strongly pressed into the central point formed in the extremity of the shaft whose velocity it is desired to measure.

Upon the upper axle, B, which is designed to show speeds of from 400 to 2,000 revolutions, are mounted a toothed wheel, D, a lead disk, which performs the *role* of a fly wheel, and a ball governor, G. The rod, H, which is connected with the governor, transmits the action of the latter by a to and fro horizontal motion to a toothed sector, K, which is continuously drawn toward its starting point by a spiral spring, L. The toothed sector itself acts upon the needle through the intermedium of the pinion, M. The axle, B', with which are noted speeds of from 100 to 500 revolutions, is provided at its internal extremity with a cog-wheel, O, which meshes

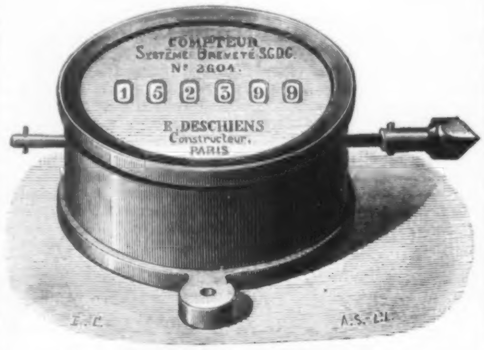


FIG. 1.—DESCHIENS'S TACHOMETER.

with the pinion, D. The speed of the governor is thus reduced to a fourth.

The summary description just given is sufficient to explain the apparatus' mechanism and mode of working. It will be readily seen that when the velocity is quickened the balls of the governor will separate more and more from the principal axis, and the needle will continually tend to get further from its starting point, and direct itself toward the high figures of the dial.

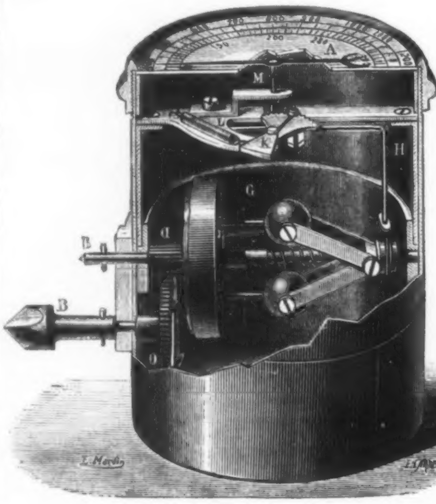


FIG. 2.

If the velocity of the machine is constant, the needle will remain stationary upon the dial; but if, on the contrary, it be modified, the variations in speed will be very clearly shown without its being necessary to recommence the verification several times in succession and during a certain time for each operation, as is practiced with the Deschiens counter.

Young's tachometer, then, is doubtless a useful and valuable auxiliary for electricians. It would be desirable, even, to have electric machines arranged so as to receive it as a permanent fixture, for it would permit the speed of their shafts to be seen at the first glance. This counter will perhaps likewise find a place upon locomotives, and upon the steam engines of shops, for permanently indicating to the engineman the velocity with which the engine is running.—*La Lumière Electrique.*

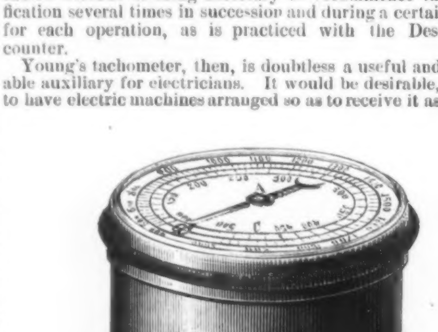


FIG. 3.

FIGS. 2 AND 3.—YOUNG'S TACHOMETER.

MILITARY TRANSPORTATION BY RAILROAD.

RAILROADS are especially remarkable by reason of the extreme facility with which they adapt themselves to the rapid carriage of large masses of travelers or materials or to any distance whatever. So this property renders them valuable from a military standpoint, for the transportation and concentration of troops, horses, and war *materiel*, and, finally, as a means of revictualing and likewise of carrying away the wounded.

The distinctive character of modern siege equipages is that they consist of colossal individual masses. Formerly it was possible, by properly dividing up the material, to carry it gradually to the theater of operations, either by the ordinary routes or by any other means; but at the present day this mode of carriage would prove radically impracticable (seeing the weight of modern weapons), and railroads, owing to their great tractive power, are alone capable of leading the enterprise to a successful termination under the conditions of celerity that are indispensable. In order to show how absolutely impossible it would be to effect a carriage and provisioning of a siege park by wagons, and upon ordinary roads, even under the most favorable hypotheses as to the number and quality of the roads, and as to the number and abundance of the resources in vehicles and draught horses, let us cite a few figures relative to the sieges of Strassburg, Paris, and Belfort, during the war of 1870–71. At Strassburg the enemy employed 373 pieces, which threw about

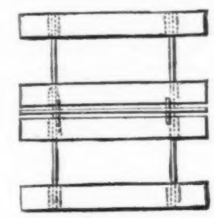


FIG. 1.—MOVABLE BENCHES.

200,000 projectiles weighing as a whole 4,000 tons. At Paris the besiegers had in battery 446 pieces, which threw 250,000 projectiles, weighing altogether 5,000 tons. Finally, at Belfort, the Germans had 228 pieces, and shot at the city no less than 410,000 projectiles, whose total weight was about 8,000 tons. Whatever be the importance of these figures, it will be seen that they do not include the weight of the *materiel* properly so called, such as guns, carriages, caissons, equipage, etc. Moreover, it may be remarked that the wars of the future have in store for us still more important figures yet, for, on the one hand, these three sieges were not carried out to their full extent, and on the other, when all places will have been provided with an equipment proportioned to present requirements, the destructive work of the besieger will necessarily be greater.

These various considerations, which give railroads a high strategic value, led to the appointment of a military commission under the presidency of General Saget, charged with studying a means of utilizing railroads to the best possible degree for military transportation. This commission presented a project which was sanctioned by a presidential decree of July 1, 1874, and completed by a new decree of Jan. 27, 1877. This is the regulation now in force.

Military transportations by rail are divided into two very distinct categories—ordinary and strategic.

Ordinary transportation is that which is effected within the interior of France, and which can be performed without interfering with the commercial business of the road. It comprises in times of peace:

1. The transportation of soldiers and sailors traveling by themselves.
2. The carriage of troops and their *materiel* by the ordinary trains.
3. The carriage of troops and their accompanying *materiel* by special trains added to those of the road's daily service, and the running of which is subordinated to that of the commercial trains.
4. Transportation of *materiel* and provisioning of all natures, soldiers and sailors traveling in a body or separately, are, along with their horses and baggage, charged but a quarter of the regular fare upon lines of importance, upon all the State lines and upon a few local ones, say 0·28 franc per

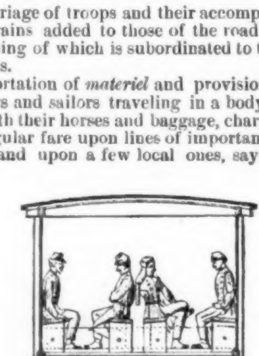


FIG. 2.—CAR PROVIDED WITH MOVABLE BENCHES.

kilometer in first class, 0·21 in second, and 0·154 in third class cars. Upon the majority of the local lines they pay half fare, say 0·056 franc in first class, 0·042 in second, and 0·0308 in third. Finally, upon some they are carried only at full rates, say 0·112 franc per kilometer in first class, 0·084 in second, and 0·0616 in third.

Strategic transportations are those that have for their object the quick concentration of large bodies of troops and *materiel* upon one or more definite points, and which usually necessitate the use of the whole or a part of the railroad company's resources in rolling stock and employes, and which consequently restrict or completely suppress the ordinary service. If need be, the government may take possession of the entire means of transportation at a company's disposal. Such a requisition is made upon the companies by a special decree of the Minister of Public Works. In this case the cost of military transportation rises from a quarter to half the normal charge for men as well as for naval or military *materiel*, on this side of the base of operations; beyond such base there is due the company only the toll tax fixed conformably to the schedule of charges.

The troops of all kinds are in time of peace exercised in embarking upon and landing from railway trains day and night. With this object in view, special shipping places have been arranged in the principal garrisoned cities, either in the vicinity of the station or upon military branches that connect the magazines of the place with the railroad; and the companies lend their aid to such exercises by furnishing them empty trains from time to time.

1. *Ordinary Transportation.*—The Minister of War and the generals in chief are the only ones who have authority to order bodies or detachments and their accompanying *materiel* to travel by rail. Orders for trains and directions for transportation addressed by these authorities to the railway companies are obligatory upon the latter.

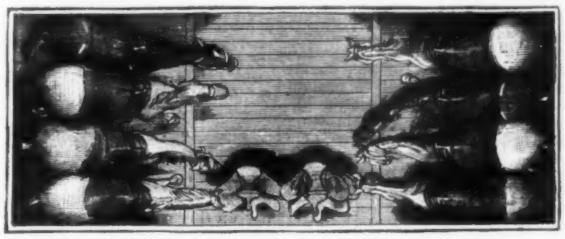


FIG. 4.—PLAN OF CAR FOR CARRYING HORSES.

Detached soldiers travel in the ordinary trains of the road; but in order to avoid the inconveniences that might result from an insufficiency of trains and from the encumberment of the station at the time of a draft of young soldiers, of a draft or sending forward of reserves, of breaking ranks, or of a return or departure of those on a furlough, the military authority advises the company, as far as possible, twenty-four hours in advance, and indicates the number of cars that are to be sent in each direction. Every detachment is provided with a collective waybill, and its commander carries the railroad checks.

When it is a question of a transportation of little consequence, and the men, horses, baggage, etc., to be carried do not require the use of more than eight cars, the military authorities may, under the same title as the public, use the ordinary trains of the road, composed of cars of all classes. But if the addition of these vehicles leads to a train composition larger than a normal one (24 cars at a maximum), the company doubles the train without the Administration of War being obliged on that account to pay for a special one. In general, the sending of any detachment of more than fifty men, as well as of any detachment having horses or carriages, must be ordered at the starting station twenty-four hours before the time set for its departure. The detachment proceeds to the station only when the latter has given notification that the means for starting have been secured. As soon as a company has agreed to transport a detachment, it cannot divide the latter *en route* in order to distribute it through different trains.

When the number of cars necessary for the transportation is more than eight, the military authority who gives the order to move is obliged to demand a special train. In all cases the movements of troops that are effected within a station must be executed in military order, under the responsibility of the chief of the detachment.

The special trains for transporting troops, etc., are divided into two categories:

1. Special trains, called *optional.*

2. Special trains, called *extraordinary.*

As a general thing, the first class cars are reserved for superior officers, and those of the second class for inferior officers, while the sub-officers and men travel in third class cars.

In large shipments of troops, strategic transportations, convocation of reserves, and of the territorial army, etc., the sub-officers and men may be shipped in covered freight cars if the number of passenger cars is insufficient. Arrangements are then so made that the men may be seated simultaneously, that is to say, eight movable wooden benches (Figs. 1 and 2) are installed lengthwise in the interior of the car. The expenses of this fall upon the Administration of War, but the company is obliged to look after the preservation of the planks and supports, and to keep them in order. The same cars are also utilized for the carriage of cavalry and artillery horses.

The freight cars arranged for the transportation of troops are lighted by means of lamps hung up in the interior, and which can be opened only by a special key, thus preventing the troops from extinguishing them. On another hand, all these cars are provided with footboards which greatly facilitate access to them.

The railway companies inscribe upon the side of the car, in a holder arranged for the purpose, the number of horses or men that it is capable of carrying. The capacity is usually thirty-two men or eight horses. This figure (32) is applicable without reduction to infantrymen (Fig. 3), and soldiers belonging to the light cavalry; but for other classes it is diminished by a fifth. As for the number of horses (8), this figure applies without reduction only to those of the light cavalry, line cavalry and artillery, of the train of military equipages, and to draught horses; it is reduced to six for reserve cavalry horses.

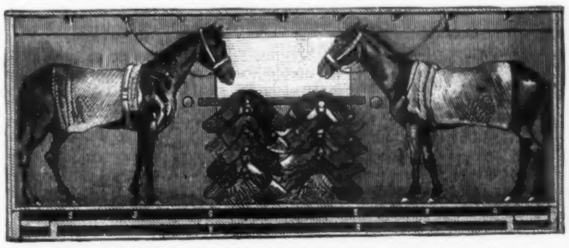


FIG. 5.—LONGITUDINAL SECTION OF CAR FOR CARRYING HORSES.

As a general rule, the army horses are placed lengthwise in the cars (Figs. 4, 5, and 6), at the rate of six reserve cavalry horses per car, or eight for other kinds. The saddles and bags of oats are placed in the same car with the horses. When the cars do not indicate how many horses they are capable of holding, the shipment is made crosswise, and the contents are calculated from the mean data. The baggage of the corps is placed in the cars employed for such a purpose in the service of the road or, for want of such, in covered freight cars.

The artillery carriages, military equipages, and bridge equipages, and generally all the carriages employed by the army, are placed upon platform cars.

The cars used for carrying the army provisions are the same as those used in the ordinary transportation of freight. The open cars are provided with awnings or tarpaulins for sheltering the food and other materials that are injured by water.

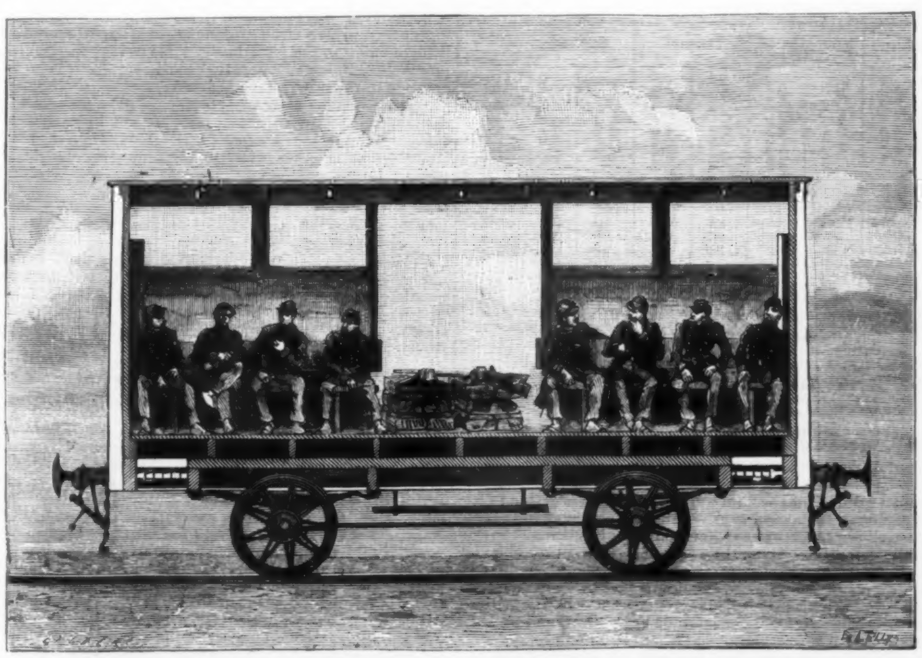


FIG. 3.—LONGITUDINAL SECTION OF CAR FOR THE CARRIAGE OF SOLDIERS.

Finally, very special precautions are taken for the carriage of gunpowder and other explosive matter.

The military trains, which contain but four passenger cars, are, as regards the total number of vehicles, considered as freight trains, that is to say, they may be composed, at a maximum, of eighty cars. When they comprise more than four passenger cars, the total number of vehicles must not exceed fifty.

For the shipping and landing of horses and carriages at stations there are used flying bridges, which are of sufficient strength to keep them from bending under the weight of the horses, etc., and which, through a gentle slope, connect the platform of the car with the ground. For shipping or landing horses at any point along the road, a movable inclined plane is used, and the same kind of an arrangement is employed for the *materiel* (Figs. 7 and 8). The flying bridges are furnished by the railroad company, which has them for its own daily use; the inclined planes are provided by the War Department.

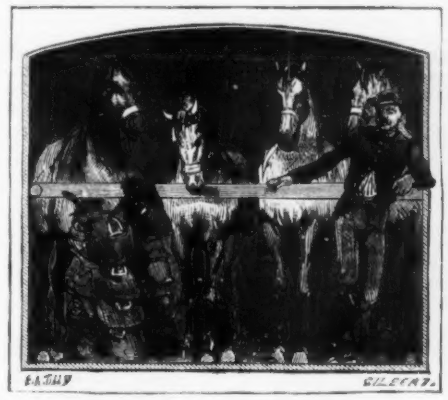
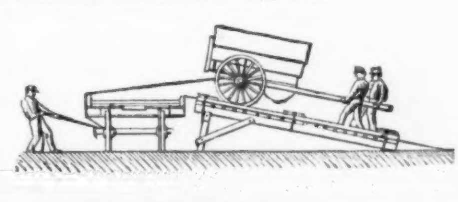


FIG. 6.—TRANSVERSE SECTION OF HORSE CAR.

The general relations of the agents of the road with the head of the troops rests upon an observance of a double principle that has in view the avoidance of conflicts. The agents of the road are in no way to mix themselves up with any question of military discipline, and the troops must in no way interfere with anything relating to the technical operations of making up and running the train. The embarking as well as the landing is effected under the orders of the detachment chief, conformably to military rules. But once the embarking finished and the doors closed, the direction of the train, during its running and up to its arrival, belongs exclusively to its conductor.

2. *Strategic Transportations.*—These are divided into two categories: (1) transportations this side of the base of operations, which are ordered by the Minister of War, and which comprise those of mobilization, concentration, victualing, and evacuation. These are executed by the companies under the direction and responsibility of the Superior Military Commission. (2) Transportations beyond the base of operations, which are ordered by the general in chief, and are executed with the ordinary *materiel* of the railroad by a special force having a military organization, under the responsibility of the direction of the country railways, with the co-operation of the military commissions of the country railways and of the military commandants of these latter. The special force under consideration consists of agents of the companies who by reason of their age are still subject to military duty, and who constitute the technical sections.

When the trip is not to take over forty-eight hours, the embarked troops receive, before starting, bread enough for the entire journey. If the trip exceeds that limit, a new distribution is made at certain stations. The men carry a cold lunch designed to be eaten *en route*, and they also receive every day, at stopping stations provided for on the time-table, coffee in the morning and a warm dinner at night. When the journey lasts more than forty-eight hours, the cold lunch consumed the first day is renewed by direct purchases made *en route*. A certain number of refreshment stations are provided in advance in strategic transportations, and each of these must be provided, according to needs, with the following: (1) a covered hall to shelter the men while eating; (2) kitchens placed as near as possible to the refectory; (3) reservoirs of potable water; (4) a provisional station ambulance; and (5) privies.



FIGS. 7 AND 8.—INCLINED PLANES.

In each of the large railway companies there is instituted a commission which is charged with all the necessary study as to how the company's *materiel* and employes can be most thoroughly utilized in the execution of strategic transportations. The object of such study is the drawing up of plans for running the trains, and of orders for moving to be sent to the troops and to the different war establishments, either for the partial or total mobilization of reserves, or the concentration of one or several army corps at definite points. These studies are made in times of peace and in a permanent manner, account being taken every year of the opening of new sections.

As soon as the companies have received from the Minister of Public Works a notification that all their means of transportation must be placed at the disposal of the Administration of War, they take all the necessary measures, with the shortest delay possible, to secure an absolute pre-eminence of military over commercial carriage. From this time on, the Military Commission exercises the most extensive pow-

ers for effecting the strategic transportations. It gives its instructions to the line commissions, who work as agents of information and control, and who themselves have authority over the halting-station agents, who are charged with distributing food, caring for the wounded and sick, and lodging troops *en route*.

When the strategic transportations occur beyond the base of operations, they are directed by the superintendency of the country railroads. This superintendency has under its orders: (1) the military commissions who are charged with the work of constructing, repairing, and destroying the road and works of art, and with the running of the trains; (2) the military commandants of the refreshment stations; and (3) a sufficient number of army officers and road agents for the accomplishment of missions and the expedition of affairs.

3. *Naval Transportations.*—The Minister of the Navy and Colonies and the prefects of the five maritime districts are the only ones who have authority to order bodies or detachments of marines and their accompanying *materiel* to travel by rail. The arrangements that we have just described are applicable to this branch of the service.—*La Nature.*

THE HEAT-CONDUCTING POWER OF MATERIALS.

ON A NEW METHOD OF MEASURING THE HEAT-CONDUCTING POWER OF VARIOUS MATERIALS, SUCH AS COTTON, WOOL, HAIR, ETC.*

By J. J. COLEMAN, F.I.C., F.C.S.

IN the last edition of the "Encyclopædia Britannica," Sir William Thomson calls attention (in the article "Heat") to unsatisfactory and inaccurate figures which have been

Fig. 1.

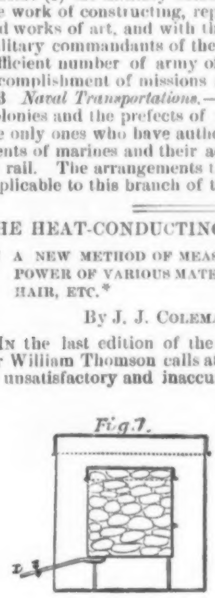
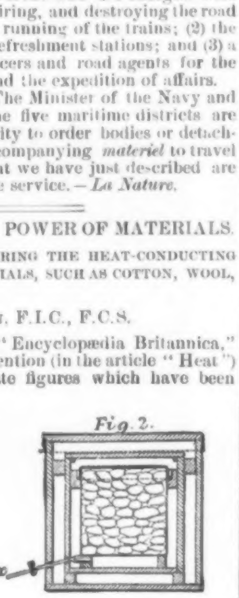


Fig. 2.



put forward by Peclet as to the conducting power for heat of various solids. In regard to metals proper, more correct results have been achieved by the late Principal Forbes, of Edinburgh, Professor Tait, and others. In all treatises upon heat Peclet's figures relating to the conducting powers of fibrous and spongy substances, such as cotton, wool, sawdust, etc., are assumed as correct, and possibly they may be, but they are deficient in giving practical information to those who require to construct insulated cold chambers for the preservation of ice, and similar technical purposes.

I have therefore had occasion to make a number of experiments on the subject, which, besides their practical utility, I venture to think are of scientific interest. The apparatus used in my first series of experiments, which were commenced in June, 1883, consisted of 10-inch cubes of thin tinplate filled with ice, placed inside 18-inch cubes of thin tinplate, the space between the two cubes being filled with the substance to be tested. (See Figs. 1 and 2.) A number of these cubes were placed side by side in a room kept at a uniform temperature of about 60 deg. Fahr., the ice melted per hour being drawn off and measured, from which the quantity of heat penetrating into the ice was easily calculated. It will be seen that this apparatus in its general features resembles the "Lavoisier Calorimeter," designed for measuring specific heat, but I am not aware that this principle has been adopted before for measuring thermal conductivity. The results of the experiments are summarized in Table I.

TABLE I.—EXPERIMENTS COMMENCED JUNE 14, 1883—4.45 P.M.

Ice Melted with different Insulators Measured in Cubic Centimetres.

DATE.	Sil. Cotton.	Hair Fel	Charcoal.	Wood Shaving.	Breeze.	Wood and Air Space.	Temp. Fahr. Outside Boxes.
	Cub. Cent. Ice Melted.	Cub. Cent. Ice Melted.	Cub. Cent. Ice Melted.	Cub Cent. Ice Melted.	Cub. Cent. Ice Melted.	Cub. Cent. Ice Melted.	Fahrenheit.
June 15, 10 a.m.	893	807	800	745	1825	1560	deg. 63
" " 6 p.m.	250	305	330	350	703	780	65
" 16, 10 a.m. .. .	815	940	942	865	1510	2220	71
" 18, 10 a.m.	1065 1540	1245 1640	1272 1870	1835 1750	2518 3050	2000 2375	
	3905	2885	3143	3085	5563	6875	

Relative Conducting Power for Heat Calculated from above Data.

Silicate cotton ..	100	Wood shavings ..	125
Hair felt .	117	Gas works breeze	230
Charcoal ..	120	Wood and air space	280

TABLE II.—EXPERIMENTS COMMENCED JANUARY 17, 1884—10.15 P.M.

Ice Melted with different Insulators Measured in Cubic Centimetres.

DATE.	Silicate Cotton.		Cotton.		Wool.		Infusor. Earth.		Charcoal.		Sawdust.	
	Cub. Cent. Ice Melted.	External Temperature Fahr.	Cub. Cent. Ice Melted.	External Temperature Fahr.	Cub. Cent. Ice Melted.	External Temperature. Fahr.	Cubic Cent. Ice Melted.	External Temperature Fahr.	Cub. Cent. Ice Melted.	External Temperature Fahr.	Cent. Cub. Ice Melted.	External Temperature Fahr.
Jan. 18, 8 a.m. to 11 a.m. ..	225	deg. 98	252	deg. 97	345	deg 97	350	deg. 98	440	deg. 98	440	deg. 98
" 2 p.m.	360	100	385	99	340	99	360	100	430	100	445	100
" 5 p.m.	275	101	355	101	430	101	390	102	445	103	450	103
" 8.30 p.m.	85	96	105	95	175	95	185	96	195	97	205	97
	945	..	1097	..	1290	..	1285	..	1510	...	1540	

Relative Conducting Power for Heat Calculated from above Data.

Silicate cotton ..	100	Infusorial earth ..	136
Cotton wool	122	Charcoal ..	160
Sheep's wool	136	Sawdust ..	163

Or the above Results Combined with those in Table I

Silicate cotton ..	100	Charcoal ..	140
Hair felt..	117	Sawdust ..	163
Cotton wool	122	Gas works breeze..	230
Sheep's wool	136	Wood and air space	280
Infusorial earth	136		

No observations were taken until the vessels charged with ice had been about eighteen hours in constant temperature of the room thus allowing equilibrium to be established. The melted ice was then carefully drawn off from the solid ice by the India-rubber pipe, *x*, provided with a clip, at 10 A.M., of the 15th of June, and the results during the subsequent 24 hours were taken as the most reliable, although for a still further period of 48 hours the observations were continued, and are recorded in the table. All the materials were dried by keeping them in a loose state in a well-ventilated room, kept warm by an ordinary domestic fire for several weeks before the commencement of the experiments.

It was now thought desirable to make a similar series of experiments in a room kept at a temperature of about 100 deg. Fahr. These were commenced on the 17th of January, 1884, and continued until the 19th, and the results are recorded in Table II. herewith. The water drawn off during the first ten hours is not included in the table, which is confined to the results obtained between 11 A.M. of the 18th and 6:30 P.M. of the same day. Silicate cotton stands again at the head of the list; and it may be well to explain that this interesting substance resembles cotton wool in appearance, and is produced in large quantities by blowing steam into melted blast furnace slag. It is therefore a glassy fiber.

As it was an interesting matter to compare sheep's wool and cotton wool accurately, care was taken that the weight of material used in each case was exactly the same for a given space filled up—3 lb. The figures of conductivity obtained represent the warmth of garments of equal thickness and of equal weights. Of course, if with the two materials the weight of the garment per square foot is identical, but the thickness different from a different style of manufacture, then these figures will be modified.

As for technical purposes, charcoal is confined between walls of wood. A larger experiment was made in the room kept at 100 deg., the inner vessel of ice measuring 22 inch cube. This was surrounded by an outer layer of charcoal, 3 inches thick, and an outer wall of wood (deal) 1 inch thick. It was found that under these circumstances the ice melted at the rate of about 1 lb. per twenty-four hours for every superficial foot of insulation.

Although silicate cotton stands at the head of the list as an insulator, 10 inches thick being equivalent to, say, 12 inches or 15 inches of wood charcoal, it by no means follows that it is always the best substance to use. To begin with, it is four times, or perhaps six times, as costly as charcoal, and has the fault of being friable and liable to fall into powder, especially if used on board ship, from the incessant motion of the vessel when out at sea.

* Read before the Philosophical Society of Glasgow.

AN ELECTRICAL ACTINOMETER.

AT the last interesting and very successful *conversazione* of the Society of Telegraph Engineers and Electricians, held under the presidency of Professor W. Grylls Adams, at King's College, one of the novelties, in fact, the leading novelty, was a new actinometer, based on photo-electric action, which was exhibited by its discoverer, Professor Minchin. The cell sensitive to blue light consisted of a glass test tube filled with alcohol and having a small quantity of nitrate of ammonia at the bottom. Two electrodes or strips of tinfoil, held in position by the cork, were immersed in the alcohol, and when one of these was exposed to a ray from an ignited magnesium wire, a current was set up in the cell sufficient to cause a considerable deflection of the needle of a sensitive reflecting galvanometer in circuit with the two tinfoil strips. In fact, the spot of light went quickly off the scale. That this effect was solely due to the blue or actinic rays of the light was demonstrated by Professor Minchin interposing a plate of orange glass between the cell and the magnesium light. The spot of light was then just seen to move; and if the glass had cut off all the blue rays, it is presumed the spot would have been stationary altogether. The strength of current is proportional to the actinic energy of the light. For measuring the effect of sunlight (or another source of illumination) during a fixed time, Professor Minchin stores the current in a condenser, and measures the discharges at the end of that time. To this end he has devised a clockwork arrangement to close a shutter automatically at the end of the specified time, and thus cut off the light from the cell.

HALL'S EFFECT.

THIS was one of the subjects of discussion of the last meeting of the American Association.

A few years ago Mr. E. H. Hall, then a student at the Johns Hopkins University, taking a thin strip of gold-leaf through which a current of electricity was passing, and joining the two terminals of a very sensitive galvanometer to two points in the gold-leaf, one on one edge, and the other on the other, choosing the points so exactly opposite that there was no current through the galvanometer, found that on placing the poles of a powerful electro-magnet, one above and the other below the strip of gold leaf, he obtained a current through the galvanometer, thus indicating that there was a change in the electric potential, due to the action of the magnet. Mr. Hall explains this change by supposing the rotation of the equipotential lines in the conductor about the lines of magnetic force. This explanation has been brought into question by Mr. Shelford Bidwell, who attempts to explain the action thus: The magnetic force acting on the conductor carrying the current would cause the conductor to be moved sideways, were it free to move; but, since it is held by clamps at the ends, the magnetic force acting upon it brings it into a state of strain, one edge being compressed and the other stretched; and Mr. Bidwell supposes the whole Hall effect to be due to thermal actions taking place in consequence of this unsymmetrical state of strain. Professor Hall, who is now at Harvard, has made some careful experiments to test this explanation of Mr. Bidwell. He used not only gold-leaf, but strips of steel, tinfoil, and other metals, and clamped them sometimes at both ends, sometimes in the middle, and sometimes only at one end; and in all cases the action was the same with the same metal, irrespective of the manner of clamping. This was strong evidence against Mr. Bidwell's position. Sir William Thomson suggested, as a further test, to bring about the state of strain, which Mr. Bidwell supposes to be the primary cause of the action, by purely mechanical means, bringing pressure to bear on one side or the other, and seeing whether the action obtained is at all commensurate with the action found by Mr. Hall.

Professor Hall then discussed an experiment by which Mr. Bidwell had obtained a reversal of the effect; and showed that the reversal was only apparent, and that when carefully examined the results of Mr. Bidwell's experiment were best satisfied by the theory of the rotation of the equipotential surfaces about the lines of magnetic force. Sir William Thomson spoke of the discovery of Mr. Hall as being the most important made since the time of Faraday. He favored Mr. Hall's explanation; though he considers Mr. Bidwell's suggestion as very important, and thinks that it will very likely be found that both the Hall effect and thermal effects have a common cause, rather than that one is to be taken to explain the other. He showed also that the mathematical examination of the subject indicates three relations to be investigated—first, the relation of thermal force to the surfaces of equal rate of variation of temperature; second, the relation of electric current to the equipotential surfaces; third, the relation of the thermal flow to isothermal surfaces. The second of these is that investigated by Mr. Hall, who has found that under the conditions mentioned the lines of flow are *not* perpendicular to the equipotential surfaces. There remains, therefore, 'work for two more Halls,' in either proving or disproving the existence of the analogous actions in these other two cases. Sir William Thomson also suggested the following exceedingly interesting mechanical illustration or analogue of Hall's effect. Let us be living upon a table which rotates uniformly forever. A narrow circular canal is upon this table, concentric with the axis of rotation of the table, and nearly full of water. After a while the water will acquire the same velocity of rotation as the table, and will come to a state of equilibrium. The outer edge of the water in the canal will then stand a little higher than the inner edge. Let us now apply a little *motive* force to the water, and by means of a pump cause it to flow in the canal in the same direction in which the table is already rotating; it is evident that it will stand higher on the outer edge, and lower on the inner edge of the canal, than before. But, should we cause it to flow in the opposite direction to the motion of the table, it will stand lower on the outer edge, and higher on the inner edge, than in its position of equilibrium.

The experiment made by Mr. Shelford Bidwell may also be illustrated by putting a partition in the canal so as to divide it into two circular concentric troughs, and making a little opening in the partition at some point; then taking two points near the opening in the partition, one in one trough and one in the other, if they are very close to the partition the point in the outer trough will be at a *lower* level than that in the inner one; but if they are not close to the partition, but one is taken close to the outer edge of the outer trough and the other close to the inner edge of the inner trough, then the point in the outer trough will be at a *higher* level than that in the inner trough, though the difference in level will be only about half of what it would have been had there been no partition separating the canal into two troughs. Professor Forbes called attention to the fact that the classification of the metals according to their thermoelectric qualities gives not only exactly the same division into positive and negative, but that the very *order* obtained in that way corresponds to that obtained by classifying according to the Hall effect, except *possibly* in the case of aluminum.

THE EARTH'S MAGNETISM.

THE six subterranean chambers at the Paris Observatory, for securing a uniform temperature, in order to study the earth's magnetism, have just been completed. The internal dimensions of each are 60 meters by 16 meters; and the walls, of concrete and millstone grit, are 1·8 meters, or 6 feet, thick. Inside the space thus formed come the inner chambers, isolated from the outer by a gallery 2 meters wide, the inner walls of similar construction to the outer, by 80 centimeters, or nearly 3 feet, thick. The height of the chambers is 3·65 meters = 12 feet, under the crown of the arch, which is 1 meter thick, covered with earth to the depth of 2 meters, turfed, and planted with shrubs. The observation chambers are destined to receive the following instruments: Recording apparatus of magnetic variations, Lamont's instruments for direct observation, and Arago's appliances. Strange to say, gas has been adopted for illumination.

AN EXTRAORDINARY EXPERIMENT IN SYNCHRONOUS-MULTIPLEX TELEGRAPHY.

By Prof. EDWIN J. HOUSTON.

A MOST extraordinary experiment, which is not devoid of practical bearings, has quite recently been made by Mr. Patrick B. Delany with his synchronous-multiplex telegraphic system, which is now in operation between Boston and Providence, a distance of about fifty miles.

As the experiment about to be described almost challenges belief in its possibility, I desire to state that I have seen it myself, and can vouch for the accuracy of the facts herein stated.

Wishing to try the adaptability to the synchronous system of the automatic repeaters employed by other telegraphic systems, whereby great distances are overcome, Mr. Delany, on three different occasions during the past two weeks, successfully employed such repeaters with his system, the last trial, viz., that on Monday, the 14th of July, being witnessed by myself.

One of the two wires erected by the Multiplex Company between Boston and Providence was divided into six separate and distinct Morse circuits. The first of these circuits, which we will call No. 1, was operated to Providence, at which place the receiving relay, on that circuit, was connected to the transmitting instrument on No. 2 circuit. In Boston the receiving relay, of No. 2 circuit, was connected to the transmitting instrument of No. 3 circuit. In Providence the receiving relay, of No. 3 circuit, was connected to same wire, so that the message traveled in its back and forth journeys between the two cities about three hundred miles, or six times the distance between the two cities.

A reference to the drawing will render the preceding explanation clearer. The synchronized distributing instruments, A and B, situated at Boston and Providence, respectively, are connected by the single main line, Q Q. The line is divided into six circuits, which we will call respectively No. 1, 2, 3, 4, 5, and 6. For the purpose of rendering the connections clearer, these six circuits have been separately represented with the synchronized distributing instruments connected therewith. It will of course be understood that but a single main line, Q Q, furnished with but two distributing instruments, viz., one, A, at Boston, and the other, B, at Providence, exists between the two cities.

This being premised, an inspection of the drawing will show that the main battery, M B, at Boston, split and grounded at X, is connected with the No. 1, No. 3, and No. 5 transmitters, which are respectively connected with the No. 1, No. 3, and No. 5 sextuplex circuits of the single main line, Q Q. At Providence the main battery, M' B', split and grounded at Z, is connected with the No. 2, No. 4, and No. 6 transmitters, which are respectively connected with the No. 2, No. 4, and No. 6 sextuplex circuits of the single main line, Q Q.

At Providence, the No. 1 receiver is connected with the transmitter of No. 2 circuit, so that a message sent from Boston by No. 1 transmitter would be received by the No. 1 receiving relay in Providence, when, by means of the local

From Providence, automatically repeated to No. 2 transmitter, and sent over main line through No. 2 sextuplex circuit to No. 2 receiving relay at Boston.

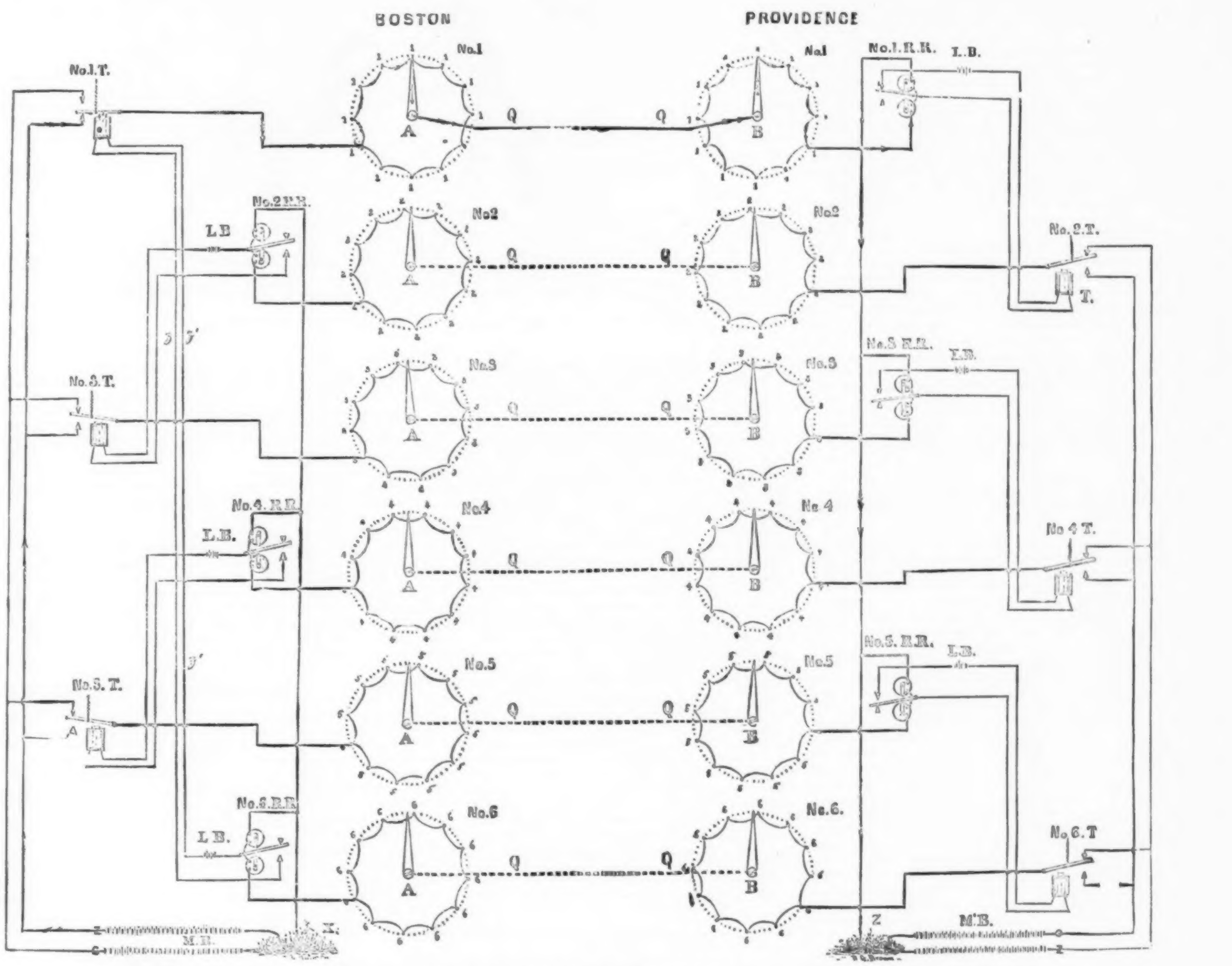
From Boston, automatically repeated to No. 3 transmitter, and sent over main line through No. 3 sextuplex circuit to No. 3 receiving relay at Providence.

From Providence, automatically repeated to No. 4 transmitter, and sent over main line through No. 4 sextuplex circuit to No. 4 receiving relay at Boston.

From Boston, automatically repeated to No. 5 transmitter, and sent over main line through No. 5 sextuplex circuit to No. 5 receiving relay at Providence.

Finally, from Providence automatically repeated to No. 6 transmitter over the main line through No. 6 sextuplex circuit to the No. 6 receiving instrument at Boston, where it is received by the operator.

It is not necessary, as might be supposed from the drawing, that the characters received on the group of segments comprising No. 1 circuit must necessarily begin to return on the next adjoining segment of No. 2 circuit. Suppose, for example, that a character concluded on the segments of No. 1 circuit, where the trailing contact indicates on the drawing. By the time the armature of the relay has moved in response to this character, and has placed No. 2 circuit in connection with the battery for return transmission, the trailing contact may be on the second or third contact of the No. 2 circuit. This, however, will make no difference, since both the distributing arms are synchronous, so long as the rotating arms pass over two or three of the No. 2 segments,



AN EXTRAORDINARY EXPERIMENT IN SYNCHRONOUS-MULTIPLEX TELEGRAPHY.

the transmitting instrument of No. 4 circuit. In Boston, the receiving instrument, of No. 4 circuit, was connected to the transmitting instrument of No. 5 circuit. Finally, in Providence the receiving relay or instrument, of No. 5 circuit, was connected to the transmitting instrument of No. 6 circuit. Under these arrangements, the transmitting instruments at both stations were operated by the receiving relays on the other circuit, the same as if worked or operated by an operator; in other words, the six separate and distinct circuits, established by the synchronizing apparatus between Boston and Providence were arranged so as to form in reality a continuous wire stretched six times between Boston and Providence, with both of its free ends in Boston.

Mr. Delany then transmitted a message on the No. 1 circuit, from Boston to Providence, which was automatically retransmitted from Providence to Boston on No. 2 circuit; again automatically retransmitted from Boston to Providence on No. 3 circuit; again automatically retransmitted from Providence to Boston on No. 4 circuit; again automatically retransmitted from Boston to Providence on No. 5 circuit; and finally automatically retransmitted from Providence to Boston on No. 6 circuit. Or, in other words, the message sent from Boston on the first circuit went to Providence, came back to Boston, again went to Providence and came back to Boston, when it again went to Providence and came back to Boston, at which final station it was clearly read by an operator without the loss of a single character, or the slightest impairing of its original clearness, and without the aid of any person except the transmitting operator on the No. 1 circuit in Boston and the receiving operator on the No. 6 circuit in Boston. All this was done over one and the

battery, L B, would have its message repeated by No. 2 transmitter, and sent to Boston over the No. 2 sextuplex circuit of the main line, Q Q. This message would be received in Boston by the No. 2 receiving relay, when by means of the local battery, L B, connected with No. 2 receiving relay, would have its message automatically repeated by the No. 3 transmitting instrument at Boston, over the No. 3 sextuplex circuit of the main line circuit, Q Q, to Providence, at which place it would be received by the No. 3 receiving relay. This relay, in its turn, through the aid of the local battery connected with it, automatically transmits the message through the No. 4 transmitter, over the No. 4 sextuplex circuit of the main line, Q Q, to Boston, at which place it is received by the No. 4 receiving relay. This relay, in its turn, through the local battery, L B, connected therewith, automatically repeats the message to the No. 5 transmitting instrument, over the No. 5 sextuplex circuit of the main line, Q Q, to Providence, where it is received by the No. 5 receiving relay. Finally this relay, in its turn, through the intervention of the local battery, L B, connected therewith, automatically repeats the message to No. 6 transmitter, over the No. 6 circuit to Boston, at which place it is received by the No. 6 receiving relay, by the operator stationed at the Morse instrument connected with that relay. This receiving relay is, in reality, shown in the drawing as connected with No. 1 transmitting instrument at Boston. The purposes secured by means of this connection will be hereafter explained.

Briefly, the course taken by the message in its journeys to and from the two cities, is as follows, viz.:

From Boston, by No. 1 transmitter over main line to No. 1 receiving relay at Providence.

while the armature of the transmitting magnet is in contact with either of the poles of the battery.

When we consider that a message made up of many words, each word containing numerous letters, each letter consisting of numerous separate and distinct characters, and each character, under the synchronous multiplex system, consisting of numerous impulses, was transmitted with certainty over a single wire, back and forth, this number of times, without the slightest interruption the one with the other, the fact almost challenges belief.

While these results may appear almost incredible, what I am about to describe may at first thought seem impossible. I will endeavor, however, to give such a description of this experiment as I saw it actually made, as will persuade the reader that, so far from being impossible, its possibility must necessarily follow as a natural result of the exquisitely maintained synchronism secured by Mr. Delany's ingenious inventions.

After having successfully established by actual trial the possibility of the use of repeaters in his synchronous system, Mr. Delany connected the relay of the sixth circuit in Boston, where the message was received, with the transmitting instrument on No. 1 circuit. Now under these conditions, on making one dot on No. 1 instrument, this dot started on its zigzag way, to and from Providence, in the manner already described, only, instead of terminating on the sixth circuit in Boston, as in the previous experiment, the same dot was automatically retransmitted into the first circuit, and again sent on its journeying between the two cities, only on its arrival at the sixth circuit in Boston to be again automatically retransmitted over this same winding route.

An inspection of the drawing will render this connection clearer. Instead of the message being received by an operator stationed at the No. 6 receiving relay at Boston, this instrument is furnished with a local battery, L B, and connected by means of the conducting wire, z z and z' z', with the No. 1 transmitting instrument at Boston. By this means, therefore, the operator at the No. 6 receiving relay is dispensed with, since this receiving relay again automatically sends the signal, by means of the No. 1 transmitting instrument, on its zigzag way between the two cities, until the No. 6 transmitter at Providence again sends it to the No. 6 receiving relay at Boston, which again automatically repeats it by the No. 1 transmitter, over the six circuits between the two cities, and so on indefinitely.

In this manner, then, the original signal kept passing from city to city, over the different circuits, in perfect rotation, without the intervention of any operator, save the one who first started the signal on its ceaseless journeyings.

Timing the intervals of the returns of the original signal between the two cities over the sextuplex circuits, it was observed that it traveled between Boston and Providence over these six circuits 300 times; or covered the distance between Boston and Providence, 1,800 times in each minute, thus making an entire distance of 1,500 miles a second, or 90,000 miles a minute; or for five minutes that a dot was kept going, the original signal in that short time traveled no less than 450,000 miles, or eighteen times as far as the entire distance around the world at the equator.

Of course it will be understood that most of this time was taken up by the automatic movements of the armatures of the receiving relays and the levers of the transmitting instruments. The experimental figures so obtained, however, furnish interesting data as to the rapidity, precision, and certainty with which these masses of matter may be influenced by the electric current.

An observer, noticing the progress of the experiment, and reflecting on the numerous complex conditions requisite for its successful accomplishment, cannot but be singularly impressed by its extreme weirdness. Bearing in mind the exceeding complexity of structure of the synchronous-multiplex message, and the necessity for maintaining practically absolute synchronism between the distributing and receiving instruments at each end of the main line, a feeling of incredulity almost unconsciously arises in the listener's mind. Surely this weird traveler must miss some of his numerous connections, and once missed, his journeys are at an end forever. But when the signals are heard recurring with their automatic regularity, as though tossed to and fro between the cities by a mighty juggler; when they are heard as mysterious whisperings in the air, that follow too rapidly on one another to permit more than a part to be intelligently received, we almost lose sight of the actual conditions of the experiment, and begin to vaguely doubt whether Mr. Delany has not received a visit from Puck, who is bewildered by the rapidity with which he is forced to travel; and when the strange repetitions of the original signal follow one another with such rapidity and regularity as to produce a kind of a prolonged, but mysterious murmur, we are almost disposed to believe that these sounds are the plaints of the Wandering Jew, as he ceaselessly speeds on his never ending journey.

Central High School, Philadelphia, August, 1884.

—*Jour. Frank. Inst.*

THE COST OF THE ELECTRIC LIGHT IN FRANCE.

A PAPER has recently been read by M. Ph. Delahaye before the Societe Technique de l'Industrie du Gaz en France, giving an account of the progress made by the electric light during 1883. He commenced by a brief account of the inventions of the year, and then turned to the question of expense, as compared with that of gas, founding his conclusions upon figures derived from typical installations. He stated that among manufacturing establishments the installation at the Cail workshops was among the most interesting, as it comprised both arc and incandescence lamps. The total superficial area illuminated is 251,880 square feet, and the number of lights 177, of which 94 are arc lamps and 83 incandescence lamps. The cost, without land and buildings, was 4,900 *l.*, and the maintenance per hour is 1·07 d. for the arcs and 0·10 d. for the incandescence lamps, the power required being 1·38 horse-power for the former, and 10 kilogrammeters for the second. The total working expense is 19 s. 2 d., or 0·003 d. per carcel hour (one carcel = 9·5 standard candles). The amortization and interest on capital, and the maintenance, taken together at 15 per cent., represent 736 *l.* Assuming a mean of 500 hours lighting per annum, there must be added on this account 0·0046 d. per carcel hour, which will bring the total cost to 0·0076 d. The total expense is 2·44 *l.* per hour, or equal to the cost of 7,167 cubic feet of gas at 6 s. 9 d. per 1,000 feet, a quantity of gas which M. Delahaye does not think will ever be brought to yield the same amount of light as is furnished by the electricity. He next takes the case of the Grand Magasins du Printemps, the lighting of which has been described in these columns.* The lights burn 5 hours per day for 300 days in the year, with the exception of thirty Jablochkoff candles in the basement, which are in use nine hours per day. The annual cost for candles, carbons, and electric lamps is 60,900 francs (2,436 *l.*); the cost of the motive power (490,065 horse-power hours) is 39,200 francs (1,568 *l.*); the expenses of the staff are 33,090 francs (1,320 *l.*); the amortization and interest at 10 per cent., 68,400 francs (2 736 *l.*): and the maintenance, at 5 per cent., 29,200 francs (1,168 *l.*). The total expense is thus 230,700 francs (9,228 *l.*). M. Delahaye institutes two comparisons between this and gas lighting. First, he estimates what would be the price of a gas installation, and what it would cost per year; and second, what consumption of gas corresponds to the light furnished by the electricity. In the former case, assuming that there would be 3,000 gas burners, giving 9·5 candles each, and taking the price of gas at 6 s. 9 d. per thousand, and adding thereto 33 per cent. for amortization, interest, supervision, etc., the yearly expense is 221,625 francs (8,865 *l.*), or almost the same as electricity. According to the latter mode of investigation, the consumption would be 69,509,760 cubic feet. At the price given above, the cost would be 31,015 *l.*, or three and a half times as much as electricity. Of course such an amount of gas could not be burnt, as it would render the place uninhabitable. M. Delahaye did not adduce any precise instance of incandescence lighting, but he gave a detailed estimate of its cost, and came to the conclusion that in an important installation it need not be dearer than gas at Paris rates, a result that will meet with very general acceptance in this country, where some have been bold enough to argue that it might compete with gas at half the price at which it is supplied in Paris. The paper is chiefly interesting in showing how favorably situated the electric light is in France, and how slow its progress is there even with the odds in its favor.

* See *Engineering*, vol. xxxvi., page 361.

TELEPHONING WITHOUT WIRES.

PROF. A. GRAHAM BELL, the inventor of the telephone, read a paper before the American Association giving a possible method of communication between ships at sea. The simple experiment that illustrates the method which he proposed is as follows: Take a basin of water, introduce into it, at two widely separated points, the two terminals of a battery-circuit which contains an interrupter, making and breaking ing the circuit very rapidly. Now at two other points touch the water with the terminals of a circuit containing a telephone. A sound will be heard, except when the two telephone terminals touch the water at points where the potential is the same. In this way the equipotential lines can easily be picked out. Now to apply this to the case of a ship at sea; suppose one ship to be provided with a dynamo machine generating a powerful current, and let one terminal enter the water at the prow of the ship, and the other be carefully insulated, except at its end, and be trailed behind the ship, making connection with the sea at a considerable distance from the vessel; and suppose the current be rapidly made and broken by an interrupter; then the observer on a second vessel provided with similar terminal conductors to the first, but having a telephone instead of a dynamo, will be able to detect the presence of the other vessel even at a considerable distance; and by suitable modifications the direction of the other vessel may be found. This conception Professor Bell has actually tried on the Potomac River with two small boats, and found that at a mile and a quarter, the farthest distance experimented upon, the sound due to the action of the interrupter in one boat was distinctly audible in the other. The experiment did not succeed quite so well in salt water.

Professor Trowbridge then mentioned a method which he had suggested some years ago for telegraphing across the ocean without a cable; the method having been suggested more for its interest than with any idea of its ever being put in practice. A conductor is supposed to be laid from Labrador to Patagonia, ending in the ocean at those points, and passing through New York, where a dynamo machine is supposed to be included in the circuit. In Europe a line is to extend from the north of Scotland to the south of Spain, making connections with the ocean at those points; and in this circuit is to be included a telephone. Then any change in the strength of the current in the American line would produce a corresponding change in current in the European line; and thus signals could be transmitted. Mr. Preece, of the English postal telegraph, then gave an account of how such a system had actually been put into practice in telegraphing between the Isle of Wight and Southampton during a suspension in the action of the regular cable communication. The instruments used were a telephone in one circuit, and in the other about twenty-five Leclanche cells and an interrupter. The sound could then be heard distinctly; and so communication was kept up until the cable was again in working order. Of the two lines used in this case, one extended from the sea at the end of the Island near Hurst Castle through the length of the island, and entered the sea again at Rye; while the line on the mainland ran from Hurst Castle, where it was connected with the sea, through Southampton to Portsmouth, where it again entered the sea. The distance between the two terminals at Hurst Castle was about one mile, while that between terminals at Portsmouth and Rye amounted to six miles.

AN ANCIENT COUNTERPART OF A MODERN TOY.

THE very curious engraving which we reproduce herewith (Fig. 1) shows once again that, as regards manners and the details of life, there is nothing new under the sun. Every one has seen in the show-windows of toy-dealers a plaything called the "wrestlers," and which consists of two little weighted and jointed figures that are set in motion by a taut string. At every tension of the latter these two little figures move about, go through the motions of wrestling, and sometimes fall on top of one another, much to the amusement of the spectator. Now it is seven hundred years ago to-day that Herrade de Lansberg, abbess of Hohenbourg, in a sort of encyclopedic compilation entitled *Hortus Deliciarum*, drew the little combatants that are reproduced in Fig. 1. This valuable MS., which was destroyed by Prussian shells in 1870, has been happily saved from absolute destruction by the copies of Mr. De Bastard that are at present preserved in the Cabinet of Prints of the National Museum. This book is a sort of abstract, in figures, of Alsatian life in the twelfth century, and games have not been forgotten therein. Herrade de Lansberg's little combatants are clad after the manner of the warriors of those times, just as in our toy—the wrestlers—the figures preserve the traditional costume of wrestlers at fairs. The two little warriors wear a helmet with nasal; and a coat of mail, a buckler, and a sword complete their equipment. Their feet, which were probably weighted with lead, kept the puppets in a vertical position, and, upon maneuvering the strings, an imitation of a sword contest was obtained.

It is probable that this toy was not a recent invention in the time of Herrade, and that the abbess of Hohenbourg only put into her drawings a costume that was already ancient.—*La Nature.*

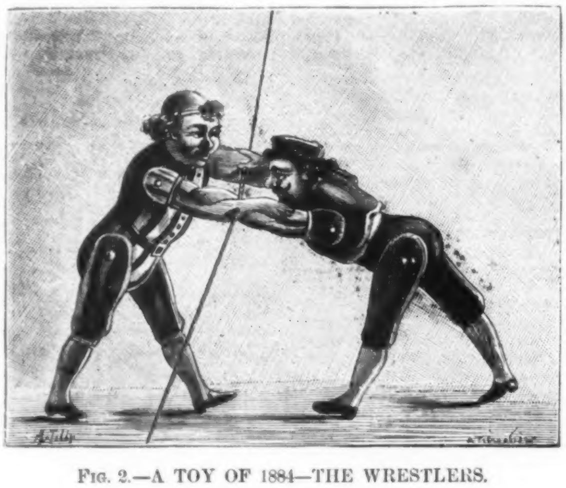


FIG. 2.—A TOY OF 1884—THE WRESTLERS.

THE LARGEST ORGAN IN THE WORLD.

AN organ recently erected in the cathedral of Riga (Russia) is claimed to be the largest in the world. A writer in the Munich *Herald* says of it: The total number of speaking stops is but 124, while there are 12 pneumatic couplers, controlled by knobs between the manuals, and 19 combination pedals. The remaining 19 so-called registers are as follows: 7 knobs controlling the manual and pedal separation, 4 swell pedals, 2 tremulants, 3 knobs controlling the grand crescendo and diminuendo, 1 dial showing the number of stops that are "on" by means of the grand crescendo, another coupler, and a tutti combination appliance for the fourth manual and pedal. The total number of pipes is 6,826. Eleven large feeders, worked by an Otto gas-motor

FIG. 1.—A TOY OF THE TWELFTH CENTURY.

of four-horse power, gather the wind into the various reservoirs, the latter having a capacity of 11,600 liters. The capacity of the largest wooden pipe—the CCC pipe of the principal bass, thirty-two feet—is 2,000 liters; and the smallest wooden pipe—the F 3 pipe of the piccolo, two feet—has a capacity of only 0·000312 liter.

A comparison of six of the larger organs now in existence may be of some interest.

The Riga organ, as stated above, has 4 manuals, each with a compass of C to F 3, and a pedal clavier with a compass of CCC to D; 124 speaking stops, 19 combination pedals, 12 pneumatic couplers, and 6,826 pipes.

The organ in the Royal Albert Hall, London, built by Mr. Henry Willis, of London, has 4 manuals, each with a compass of C to C 4, and a pedal clavier with a compass of CCC to G; 111 speaking stops, 13 mechanical registers, 19 combination pedals, and 32 pneumatic combination pistons, worked by knobs between the manuals.

The organ in the Church of St. Sulpice, Paris, was entirely reconstructed in 1857–62, by M. Cavaillé-Coll, of Paris, and now has 5 manuals, each with a compass of C to G 3, and a pedal clavier, with a compass of CCC to F; 100 speaking stops, 18 mechanical registers, 20 combination pedals, and 6,706 pipes.

St. George's Hall, Liverpool, has an organ, built in 1855, by Mr. Henry Willis, and reconstructed by him under the supervision of Mr. W. T. Best, in 1867, which has 4 manuals, each with a compass of GG to A 3, and a pedal clavier with a compass of CCC to F; 100 speaking stops, 42 combination pistons worked by knobs, 10 mechanical appliances, and 6,957 pipes.

The organ in the cathedral of Ulm, Würtemberg, built by Messrs. Walcker & Co., in 1858–56, has 4 manuals, 2 pedal claviers, 100 speaking stops, 9 mechanical stops, and 6,564 pipes.

The Town Hall of Leeds, England, has an organ, built in 1857–59, by Messrs. Gray & Davidson, which has 4 manuals, each with a compass of C to C 4, and a pedal clavier with a compass of CCC to F; 100 speaking stops, 17 mechanical registers, 17 combination pedals, and 6,500 pipes.

THE NATIONAL ACADEMY OF SCIENCES.—MEETING AT NEWPORT, OCTOBER 14, 15, AND 16, 1884.

THE last report of the Academy thus succinctly states its nature and object:

"The National Academy of Sciences was established by act or Congress in March, 1863, with power to frame its own constitution, select its own members, and provide in other respects for its continuance and successful operation.

"The object of the Academy is to advance science, and especially to investigate, examine, experiment, and report on any subject of science or art whenever called upon by any department of the Government.

"The Academy contains, at present, about one hundred members, and these have all been selected for their original researches in science. They represent within their ranks nearly every department of knowledge, and their services, in accordance with the charter of the Academy, are always at the disposal of the Government, without compensation."

The constitution provides for one stated session at Washington on the third Tuesday in April of each year, and permits another at such time and place as the Council may determine. For the first nine years of its existence, the Academy held only the Washington session; but, in 1872, and in every subsequent year, it has held also an autumnal session, usually at New York or Philadelphia.

The whole number of papers and reports presented from its organization in 1863 until the close of 1883 was 777.

The report for 1883 embodies two reports, in response to inquiries from the Commissioner of Internal Revenue: the first one in regard to methylated spirits, or the separation of methyl alcohol, or wood spirits, from ordinary (ethyl) alcohol; the second in regard to glucose. The question as to wood spirits was whether it is possible to purify alcohol from its taste and smell or not, in order that Congress might act intelligently on a bill to release from bond alcohol thus admixed. The committee report that it is possible to reduce the taste and smell to a minimum, although an expert could readily detect the residual flavor. Of glucose, they conclude:

1. That the manufacture of sugar from starch is a long established industry, scientifically valuable, and commercially important.

2. That the processes which it employs at the present time are unobjectionable in their character, and leave the product uncontaminated.

3. That the starch sugar thus made and sent into commerce is of exceptional purity and uniformity of composition, and contains no injurious substances.

4. That though having at best only about three-fifths the sweetening power of cane sugar, yet starch sugar is in no way inferior to cane sugar in healthfulness, there being no evidence before the committee that maize starch sugar, either in its normal condition or fermented, has any deleterious effect upon the system, even when taken in large quantities.

Papers were read as follows: The Brain of Asellus and the Eyeless Form Cecidotæa, by A. S. Packard, discussed by Prof. Scudder. On the Complex Inorganic Acids, by Wolcott Gibbs. On the Thinolite of Lake Lahontan, by E. S. Dana, discussed by O. C. Marsh and W. H. Brewer. Prof. Marsh considered it the most interesting *chemical* problem presented by the fresh water lakes.

On Wednesday papers were read by Prof. E. D. Cope on The Columella Auris of the Pelycosauria, by Prof. Fairman Rogers; on Muybridge's Experiments on the Motions of Animals by Instantaneous Photography; and by Prof. E. B. Tylor on The Civilization of the Native Peoples of America. Among the papers entered to be read at the present session were the following:

On the Columella Auris of the Pelycosauria, by E. D. Cope. The Brain of Asellus and the Eyeless Form of Cecidotæa, by A. S. Packard. On the Theory of Atomic Volumes, by Wolcott Gibbs. On the Complex Inorganic Acids, by Wolcott Gibbs. Notice of Muybridge's Experiments on the Motions of Animals by Instantaneous Photography, by Fairman Rogers. Notice of Grant's Difference Engine, by Fairman Rogers. On the Thinolite of Lake Lahontan, by E. S. Dana. On the Mesozoic Coals of the Northwest, by R. Pumpelly. On the Work of the Northern Transcontinental Survey, by R. Pumpelly. The Grasses Mechanically Injurious to Live Stock, by Wm. H. Brewer. On Gravitation Survey, by C. S. Peirce. On Minimum Differences of Sensibility, by C. S. Peirce and J. Jastrow. Researches on Ptolemy's Star-Catalogue, by C. H. F. Peters. On the Operations of the United States Geological Survey, by J. W. Powell. The Motion of Hyperion, by Asaph Hall. Remarks on the Civilization of the Native Peoples of America, by E. B. Tylor. Some Results of the Exploration of the Deep Sea beneath the Gulf Stream, by the U. S. Fish Commission Steamer Albatross during the past Summer, by A. E. Verrill. Recent Progress in Explosives, by H. L. Abbot. On an Experimental Composite Photograph of the Members of the Academy, by R. Pumpelly. Report on Meridian Work at Karlsruhe, by W. Valentiner. On the Algebra of Logic, by C. S. Peirce. The Temperature of the Moon, by J. P. Langley.

THINOLITE OF LAKE LAHONTAN.

By Prof. E. S. DANA.

LAKE LAHONTAN is the name given by Mr. Clarence King to the great Quaternary lake in western Nevada, of which Pyramid, Humboldt, Carson, etc., Lakes are the relics. As shown by Mr. King, the Lahontan basin is characterized by great deposits of calcareous tufa, to which he gave the name *thinolite*, as being a shore deposit; this tufa forms beds along the shore of the former lake, several hundred feet thick. This tufa is in part crystallized, and Mr. King explained it as having been derived from the alteration of gaylussite, a carbonate of calcium and sodium. The same field has been recently thoroughly studied by Mr. I. C. Russell, of the U. S. Geological Survey, who has mapped out the lake area and the terraces. Mr. Russell has shown that the calcareous tufa is of three kinds, in order of deposition the *lithoid*, the crystalline or *thinolite*, and the *dendritic*. He has shown also that the changes supposed by Mr. King to account for the alteration of gaylussite to calcium carbonate cannot have taken place. The study of the crystals of thinolite was undertaken first to make out their original form and also their original chemical composition. The skeleton forms now remaining are shown to belong to an acute square pyramid, a form which proves that the original mineral was not gaylussite, nor any other known mineral which could be suggested as an explanation. The similarity of the thinolite crystals to some pseudomorphs of lead carbonate after a mineral called phosgenite, a chlorocarbonate of lead, has led to the hypothesis that the original mineral may have been a chlorocarbonate of calcium isomorphous with phosgenite, and in an analogus manner altered to calcium carbonate.

ON THE STRUCTURE OF THE BRAIN OF THE ASELLUS AND THE EYELESS FORM CECIDOTÆA.

By A. S. PACKARD.

THE results presented grew out of an attempt to compare the nervous system, particularly the brain and other cephalic ganglia, of the eyeless species of cave-inhabiting crustacea and insects with the allied eyed forms. After describing the brain and organs of sight of the common water row-bug (*Asellus communis*), with it was compared those of the blind asellid, *Cecidotœa stygia* of Packard, which is so common in the brooks of Mammoth and other caves, and in the wells of southern Illinois and Indiana. Studies of this nature seem well calculated to throw light on the origin of the cave forms, and to show what great modifications have been produced in these organisms by a radical change in their surroundings; consisting as the latter do mainly of the absence of light and perhaps of the usual food, or at least the usual amount of food.

After describing the hitherto unknown peculiarities of the brain of asellus and Isopod crustacea in general, the histological elements, and the optic lobes, nerves, and eyes, the brain of the eyeless forms was then described. Cecidotœa in its external form is a somewhat dwarfed asellus, with the body, however, much longer and slenderer than in the eyed forms, and with slenderer appendages. It is not usually totally eyeless, since in some individuals a rudimentary eye, in the shape of a minute black speck, is seen on each side of the head; the spot varying in size in different individuals.

From the examination of numerous microscopic sections it appears that the eyeless Cecidotœa differs from the eyed form (asellus) in the complete loss of the optic ganglia, the optic nerves, besides the almost and sometimes nearly total loss of the pigment cells and lenses. As regards the other parts of the brain, no differences were observed; the proportions of the brain and the histological structure had remained unchanged in the eyeless forms. Besides the atrophy of the optic ganglia and nerves, the pigment mass forming the retina and also the lenses exist in a very rudimentary condition. In our specimen the number of lenses was reduced to two, and the lenses themselves many times smaller than in the eye of the normal asellus.

The steps taken in the degeneration or degradation of the eye, the result of living in perpetual darkness, seem to be these:

1. The total and nearly or quite simultaneous loss by disuse of the optic ganglia and nerves.

2. The breaking down of the retinal cells.

3. The last step being, as seen in the totally eyeless forms, the disappearance of the lens and retina.

That these modifications in the eye of the Cecidotœa are the result of disuse and the loss of the power of vision from the absence of light seems well established; and this, with many parallel facts in the structure of other cave crustacea, as well as insects, arachnids, and worms, seemed to the author to be due to the action of two factors: (*a*) change in the environment and (*b*) heredity. Thus one is led by a study of these instances, in a sphere where there is little if any occasion for the exercise of a struggle for existence between the organisms, to a modified, modern form of Lamarckianism in order to account for the origination of these forms, rather than the theory of natural selection, or pure Darwinism, as such.

ON THE CIVILIZATION OF THE NATIVE PEOPLES OF AMERICA.

By E. B. TYLOR, Prof. of Anthropology, Oxford, Eng.

I SUBMIT such very slight remarks as present themselves to me on my visit to America, and especially on the tribes which we visited—the Zuni, Navajo, Mojave, and Wallopi.

At Montreal Prof. Moseley and I had a thorough look at the Ojibway Indians. If their costume had been arranged to suit, many of them, and especially the younger, might have passed as Thibetans or Mongolians of Northern Asia.

As we neared the Pacific, the resemblance faded. The nose became more aquiline and the features darker. Prof. Moseley, who has seen Malays, as I have not, thought that their features resembled the Malays.

The idea remained in our minds, though put to a severe test. We often saw the Chinese within a yard or two of the genuine Indians. Everything was unfavorable to a view of close approximation, and certainly the Chinese was very much varied from the tribes of the north.

Whether it is that long ages of civilization have given delicacy and astuteness to the complexion we cannot tell.

This study has received improvement from the suggestion of Prof. Marsh as to the tertiary bridge which united Asia and America, many ages before, whereby interchanges of animals must have gone on. If that was there during tertiary and quaternary periods, the difficulty of populating America is solved.

That some such movement took place is almost proved by the study of language. Where it is possible to get together the members of a widely scattered family, like the Athabascan, where formerly philologists have failed to notice resemblances, the careful way in which languages are now studied has revealed them.

The Iroquois and Algonquin still speak languages which seem to present no tangible resemblances. If these tribes came from Algonquin, the period of separation must have been very remote. Or if we suppose that in the old continent the languages were very diverse, either hypothesis will answer to explain existing conditions.

Migration by canoe is possible, yet such secondary migration cannot satisfy the anthropologist. We must look for a different configuration of land and water from those now found.

This brings me to the perplexing question of the civilization of the lower races in America.

We observe things like those in remote antiquity. In Mojave a man refused me a lock of hair, for fear he would become blind and deaf, and the medicine man would come and blow, and could not blow away the evil spirit. The same theory of disease as caused by evil spirits prevails among Italians and some other European nations, and they are just as averse to parting with any of their hair, for the same reason.

Lately, biologists who have to deal with the problem I have to state, have introduced words for it. Why do the Mojave and the Italian coincide? Is it from unity of race or similarity of condition? Ray Lancester has proposed the terms homogeny and homoplassy. Homogeny (or if we dislike that on account of its resemblance to homogeneous, we may substitute homogenetic) denotes resemblances which are derived from unity of origin; homoplassy (or homoplastic) denotes those resemblances which I ascribe to what I call natural formativeness under similar conditions. The problem of distinguishing between the two kinds of similarity is not insoluble.

Dr. Yarrow once put a case to me. He had been attending a burial among the Utes. They bury in streams. It was not generally done, but when they buried a man who was hated, in order to get rid of his ghost they buried the man in the water, so that his soul remained there. I said I think I know something like this in West Africa. But it is different. It comes from an old account of a traveler there. The widow would go into water with the idea that her husband's soul was still clinging to her, and she could wash it off, and be free to marry. These customs cannot represent heredity, but these people, though not akin, both have an idea that the spirit or ghost can be got rid of by drowning.

It is a popular idea all over the world that ghosts cannot pass water, so that in various districts bridges, sometimes only a fine wire, are put across the streams for them to pass over. Catlin mentions the bridge of the dead among the American Indians. Among Europeans we find the superstition that the spirits of the wicked cannot cross the thread, but fall into the water. This seems like a case of homoplassy.

Two ways have suggested themselves besides this way of determining which races are connected by homogeny and which by homoplassy.

Among the Dutch possessions in the Eastern Archipelago is society in which maternal descent prevails. Most of the Indian tribes we visited are on this basis.

There was one exception, the Ojibways that we saw first. One of them told me he was a badger. I said, "That was your mother?" He replied, "No, my father."

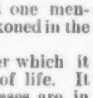
Maternal descent among the tribes I visited is not in a primitive state. It is very much broken down. The Dutch have published an account of very archaic life among the Malays, where maternal descent prevails in a more primitive condition. Each household is classified maternally. The man lives in the house of his great-great-grandmother; in some cases with the girl he marries. A curious point is that marriage does not bring on housekeeping. She remains home, and he remains home. Society is in that rudimentary state. The father has no authority. If he claimed any, the maternal uncle would soon interfere. One would say this state of things comes from human nature, as it comes also from the Eastern Archipelago.

In southeastern Asia there is a great deal of totemism.

Among all the nations of the old world, except one mentioned by Herodotus—the Lycians—descent is reckoned in the paternal line.

Maternal descent has a geographical region over which it prevails. It may represent a hereditary state of life. It does affect a problem of this kind when all the cases are in a particular geographical area.

For instance, I notice with surprise that there existed among the Indians a still known diagram, the five-pointed star known to magicians. It comes in about the time of the Christian era. It is the sign of the Pythagoreans, by which they know one another. It is nothing but a geometrical figure. It is the triangle of Euclid repeated three times. In the old world, nothing is more likely than that one should find this pentagon repeated in charms, etc. Lately, however, one was found out West, and I adduced this on one occasion as an example of the way in which the white man's influence had got among the Indians. To my surprise, this argument was received with great incredulity, and I was met with the argument that men would naturally draw pentagons. I put the question before the meeting as an example of the need of support by a hypothesis.



The request that anthropologists make of antiquaries and of biologists is that they shall give to anthropology what it has not yet got, mathematical precision, to give means of settling inquiries and getting this subject in better working order during our lifetime.

My object was to show this morning how anthropologists have to work in a very rough way by the mere rule of thumb, and it would be desirable for them to secure some more accurate method.

GRAVITATION SURVEY OF THE UNITED STATES.

By C. S. PEIRCE.

MR. PEIRCE gave an account of the gravitation survey of the United States. It is proposed to cover the country with stations at which gravity shall be determined at distances of about two hundred miles. About regions of geological dis-

turbance, such as great faults, and where there are mountains or other disturbing causes, the stations must be nearer together. The design is to collect sufficient data to draw the isobaric curves, along each of which the force of gravity, after correction for elevation and latitude, is constant. These curves will afford the means of ascertaining the precise figure of the *geoid* (*i. e.*, the level surface of the sea continued under the continents), and this in its turn will have an important bearing upon geological theories, upon geodetical determinations, etc. Thus far the work has been retarded by the necessity of completely reforming the methods used in Europe for measuring the force of gravity, in which very grave errors have been detected. Mr. Peirce announced that he had discovered a new and considerable source of error in the flexure of the pendulums themselves which have been used for the determinations. The new pendulums now getting constructed for the United States Survey are not open to this correction. Gravity has already been determined at twenty-eight stations, the results for eight have been published, and the remainder will appear within a year. When the necessary apparatus has been received and found satisfactory, with yearly appropriations of four thousand dollars above the yearly expense of transportation, eight or nine stations will be occupied each year, and the work soon brought to completion.

Professor C. S. Peirce read a paper "On the Algebra of Logic" This memoir, which is highly mathematical, is part of an investigation into the methods of reasoning used in different branches of mathematics. Mr. Peirce remarked that no progress was made with the theory of numbers until Fermat discovered a peculiar form of reasoning, by the use of which the branch of mathematics in question was rapidly developed. In the same way, the theory of linkages and parallel motion had been kept back by ignorance of the proper form of reasoning. All mathematical reasoning requires the use of signs or symbols of three distinct kinds. The first are general signs such as compose the body of speech, and the symbols of differentiation, integration, etc., in algebra. The second are signs directing the attention to their objects, and distinguishing them, without describing the distinctions, by virtue of some real connection with them. Such are all natural signs and symptoms ; also pronouns, the letters of a geometrical diagram, the subscript numbers in algebra, etc. The third are signs which represent their objects by virtue of presenting some similarity or analogy to them. Such are the diagrams of geometry, the arrangements of algebraical formulae, etc. These signs, called *icons* by Prof. Peirce, are shown to be absolutely essential to all reasoning. In fact, all mathematical deduction consists in observing something to be true with regard to such an *icon*, and consequently true likewise of the object or reasoning. The most rudimentary *icon* is a syllogistic form, where the arrangement of the letters presents an analogy with the relations of the terms of reasoning. A method for investigating *icons* is given, together with a list of some twenty of them, used in different parts of mathematics, and representing essentially different forms of relationship irreducible to one another. The class of problems for which each of these is indispensable is also specified ; and examples of the application of the theory to the resolution of several intractable problems are given. The paper will be published in the forthcoming volume of the Memoirs of the Academy.

Mr. Peirce read a paper by himself and Mr. Joseph Jastrow upon least perceptible differences of sensation. The German physiological psychologists assume that there can be two different intensities of nerve-excitation of so nearly the same value that the sensations they produce shall be absolutely indistinguishable. On the other hand the astronomers and physicists employ the method of least squares, according to which there is no difference of excitation so slight that a sufficient number of observations will not detect it. Probably neither party would insist dogmatically upon the accuracy of its assumption, and the researches of Messrs. Peirce and Jastrow are the first hat have been undertaken in order to decide which is right. The psychologists have assumed that when we feel quite uncertain as to which of two weights, for instance, is the heavier, the sensations they excite are identical. To find whether this is so, two weights differing by a small amount have been brought (with a variety of precautions, fully described in the paper) successively upon the finger of an observer, who has stated which he thought was the heavier, and also stated (by the use of an arbitrary numerical scale) the degree of his confidence in his judgments. The differences of the weights were so small that the observer had not the slightest consciousness of feeling anything, so that it seemed to him nonsensical to attempt to say which was the heavier. Nevertheless he gave what he thought a random answer, and it was found in each case he answered more often right than wrong. Moreover, upon calculating by least squares his "probable error," that is to say, the ratio of weights which he would be able to discriminate rightly seventy-five times out of a hundred, the value so calculated was found to agree with direct observation, or, what comes to the same thing, a "probable error" could be assigned from which, by means of the theory of least squares, the proportions of erroneous judgments for different ratios of weights could be calculated with approximate accuracy. The following tables show this:

SUBJECT: MR. PEIRCE.

Ratios of weights.	1100/1000	1080/1000	1060/1000	1050/1000	1040/1000	1030/1000	1015/1000
No. of sets of 50 obs'ns.	1	1	7	1	1	6	5
Observed number errors per set.	2	4	10·4	13	15	19·3	21·6
Calculated No. for Prob. error =0·051	4·6	7·2	10·7	12·7	14·9	17·2	21·0

SUBJECT: MR. JASTROW.

[The observations of Mr. Jastrow are divided into four groups, because the accuracy of his sensibility underwent gradual change.]

First Group.

Ratios of weights.	1100/1000	1080/1000	1060/1000	1050/1000	1040/1000	1030/1000	1015/1000
No. of sets of 50 obs'ns.	1	1	7	1	1	6	5
Observed average No. errors per set.	5	9	11·0	19	15	13·8	20·8
Calculated number for Prob. error =0·05	4·4	7·0	10·4	12·5	14·7	17·1	21·0

Second Group.

Ratios of weights.	1060/1000	1030/1000	1015/1000
No. of sets of 50 obs'ns.	5	5	5
Observed average No. errors per set.	2·2	9·4	17·0
Calculated number for Prob. error =0·023.	2·1	9·6	16·6

Third Group.

Ratios of weights.	1020/1000	1010/1000	1005/1000
No. of sets of 50 obs'ns.	6	6	4
Observed average No. errors per 50	12·8	17·7	20·7
Calculated number for Prob. error =0·02.	12·5	18·3	21·6

Fourth Group.

Ratios of weights.	1060/1000	1030/1000	1020/1000	1015/1000	1010/1000	1005/1000
No. of sets of 50 obs'ns.	1	1	6	1	6	6
Observed average No. errors.	0	5	10·0	14	16·0	20·2
Calculated number for Prob. error =0·0155	0·8	4·8	9·6	12·8	16·5	20·6

It was found that whenever the difference between the weights was less than half the probable error, the degree of confidence was always marked *zero*, implying that the judgment seemed a purely random guess, or was very rarely marked 1, implying a slight suspicion of consciousness of a difference. Hence it appears that the assumption of least squares is correct, and that an *Unterschiedsschwelle* does not exist.

Dr. Gibbs read a paper on Atomic Volumes, in which he endeavored to show that the received views upon this subject are radically incorrect, inasmuch as no account is taken of the distinction which must be drawn between molecular and intermolecular, or interstitial, space. He showed that since the space occupied by the molecules of hydrogen in a cubic meter of that gas at the normal temperature and pressure is 0·0007 of the whole space, or 700 cubic centimeters, and since the weight of a cubic meter is 89·6 grammes, the absolute specific gravity of the molecules of hydrogen is 0·128, water at 4° C. being taken as unit; and that since the atomic weight of hydrogen is unity, the relative atomic volume of hydrogen is 1 : 0·128, or 7·81. The determination of the molecular volume of hydrogen in a cubic meter of the gas depends upon the assumption that the molecules exert no sensible action upon each other, and is therefore subject to correction. He showed that the molecular volumes of gases could be determined in certain cases, but that at present we have no means of arriving at those of solids or liquids.

The following notice of Grant's Difference Engine was made by Mr. Fairman Rogers:

The Difference Engine, for the purpose of calculating any tables which can be made by the method of differences, was first exhibited at the Centennial Exhibition in 1876. It was theoretically satisfactory, but its mechanical construction was found defective in practice. The machine has been entirely redesigned and the old one destroyed, and the new one, which is nearly completed, promises to be free from the old defects. It is much smaller, simpler in construction, and with no parts that are liable to get out of order. As the engine not only calculates the terms of the tables, but prepares a wax mould, from which the electrotype for printing can be taken, the results will at least be free from errors introduced by copyists or printers.

Mr. Fairman Rogers made the following remarks in reference to the experiments of Muybridge on the motions of animals by instantaneous photography. After the considerable time elapsed since the first experiments, Mr. Muybridge has resumed them this summer in Philadelphia, under the auspices of the University of Pennsylvania. No especially new system is used, but the apparatus has been perfected in many details, and dry plates are used, so that superior results may be looked for. While many instantaneous photographs of animals in motion existed before those made by Muybridge, they were mere isolated attitudes of motion, giving very little information, while his, being consecutive, and taken at equal intervals of space or time, give all the information regarding the different phases of the motion.

It is perfectly possible to apply this method to the study of all kinds of motion, and it must come into use for that purpose. It would be useful, for instance, to study in this way the propelling action of the tails of fishes, with a view of determining the proper form for screw propellers, which will not only give good results in economic propulsion, but will avoid the vibrations accompanying high speeds. It is with a view of attracting the attention of the members of the Academy to the value of this method of investigation that the subject is again referred to before it.

SOME RESULTS OF THE EXPLORATION OF THE DEEP SEA BENEATH THE GULF STREAM BY THE U. S. FISH COMMISSION STEAMER ALBATROSS DURING THE PAST SUMMER.*

By A. E. Verrill.

THE exploration of the Gulf Stream region was continued this season, under nearly the same conditions as in 1883, by the steamer Albatross, Lieutenant Z. L. Tanner commander. During the four trips, between July 20 and September 18, sixty-nine dredgings were made (stations 2,170 to 2,238). In most of these a large beam-trawl was used very successfully, even at great depths.

Of these dredgings, 5 were in depths between 2,000 and 2,600 fathoms (4 successful); 20 were between 1,000 and 2,000 fathoms; 24 between 500 and 1,000 fathoms; 8 between 300 and 500 fathoms; 12 between 75 and 300 fathoms. Another trip has since been made to explore more extensively the zone between 40 and 100 fathoms. On this trip about 24 additional dredgings were made, but the results are not yet worked out. The first trip was made while the steamer was on her way north from Norfolk, Va., and some of these stations were off the coast of Maryland, the most southern being in N. lat. 37° 57', but most of the others have been made in the region south and southeast of Martha's Vineyard, though some of them were a long way off the coast. The five stations in depths below 2,000 fathoms were more than half way to Bermuda, and nearly east of the coast of Virginia, between N. lat. 36° 5' 30" and 37° 48' 30", and between W. long. 68° 21' and 71° 55'.

The results are highly satisfactory, both in the way of physical observations and zoological discoveries. Large numbers of additions have been made to the fauna, including representatives of nearly all classes of deep-sea animals. Many pelagic species were also secured in the surface nets, and especially in the trawl-wings, among which there are some new forms and many that have not previously been observed so far north in the Gulf Stream.

CHARACTER OF THE DEEP-SEA DEPOSITS.

Some very interesting and important discoveries were made in regard to the nature of the materials composing the sea-bottom under the Gulf Stream at great depths. These observations are of great interest from a *geological* point of view, and some of them are contrary to the experience of other expeditions, and not in accordance with the generally accepted theories of the nature of the deposits far from land. The bottom between 600 and 2,000 fathoms, in other regions, has generally been found to consist mainly of "globigerina ooze," or, as in some parts of the West Indian seas, of a mixture of globigerina and pteropod ooze. Off our northern coasts, however, although there is a more or less impure globigerina ooze at such depths, at most localities beneath the Gulf Stream this is by no means always the case. The ooze is always mixed with some mud and sand, and frequently with much clay-mud. In a number of instances the bottom at depths below 1,000 fathoms has been found to consist of tough and compact clay, so thoroughly hardened that many large angular masses, sometimes weighing more than fifty pounds, have been brought up in the trawl, and have not been washed away appreciably, notwithstanding the rapidity with which they have been drawn up through about two miles of water. In fact these masses of hard clay resemble large angular blocks of stone, but when cut with a knife they have a consistency somewhat like hard Castile soap, and in sections are mottled with lighter and darker tints of dull green, olive, and bluish gray. When dried they develop cracks, and break up into angular fragments. This material is genuine clay, mixed with more or less sand, showing under the microscope grains of quartz and feldspar, with some scales of mica. More or less of the shells of *globigerina* and other foraminifera are contained in the clay, but they make up a very small percentage of the material.

The following are some of the special localities where these clay masses were taken:

Station 2,192, in 1,060 fathoms, N. lat. 39° 46' 30", W. long. 70° 14' 45". Large blocks of sandy clay, some weighing about 100 pounds. It was estimated that about a ton was brought up.

Station 2,230, in 1,168 fathoms, N. lat. 38° 27', W. long. 73° 2'. Large quantity of masses of hard but sticky greenish blue clay, some masses varying to yellowish and buff colors.

Station 2,171, in 444 fathoms, N. lat. 37° 59' 30", W. long. 73° 48' 40". Large lumps of bluish gray sandy mud.

In other localities, below 1,000 fathoms, the bottom is covered with, or largely composed of, hard, very irregular, flattened, crust-like concretions of clay and iron oxide, with more or less manganese oxide in the crevices and worm-burrows with which they are filled. At some localities a barrelful, or more, of such masses was brought up, varying in size from a few ounces up to 20 pounds or more in weight, and from an inch to six inches in thickness.

The following are some of the localities where such materials occurred:

Station 2,208, in 1,178 fathoms, N. lat. 39° 33', W. long. 71° 16' 15". Large quantities of hard, crusty, ferruginous clay. Also a rounded granite bowlder, weighing over 20 pounds.

Station 2,228, in 1,582 fathoms, N. lat. 37° 25', W. long. 73° 6'. Large quantities of irregular crusty and cavernous concretions and masses of ferruginous clay, with considerable black manganese oxide lining the holes and cracks. The lower side of many of the masses consisted of sticky bluish clay. It was estimated that about a ton of this material came up. There were some corals, gorgonians, hydroids, bryozoa, and the brachiopods *Discina Atlantica* and *Waldheimia cranium* adhering in considerable numbers to these hard masses.

Rounded bowlders and pebbles of granite, gneiss, and other crystalline rocks occurred at a number of stations. One bowlder, from station 2,208, is referred to above.

The following are other localities:

Station 2,195, in 1,058 fathoms, N. lat. 39° 44', W. long. 70° 3'. A rounded granitic bowlder, about four inches in diameter. Its surface was covered with adherent species of foraminifera and some annelid tubes.

Station 2,226, in 2,021 fathoms, N. lat. 37° 0'; W. long. 71° 54'. A large number of pebbles and small, rounded bowlders of granite, porphyry, etc., and some coal-cinders. The pebbles were more or less covered with adherent foraminifera, bryozoa, etc.

Scattered bowlders and pebbles have also occurred at many other localities along the inner edge of the Gulf Stream. These have probably all been carried out there by ice from the adjacent coasts, in spring.

A curious case, quite unique in our experience, of the occurrence of abundant relics of human handiwork was observed this year at station 2,221, in 1,525 fathoms, N. lat. 39° 5' 30", W. long 70° 44' 30", beneath the Gulf Stream, a large quantity of common bricks, with mortar and soot still adhering to them, was brought up in the trawl. Some were nearly entire, but most were in fragments. Annelid tubes, brachiopods, and other forms of deep sea life were attached to them in small quantities, showing that they had not been on the bottom very long. These may have come from some wreck, or they may have formed the deck-furnace of some whaling vessel, and have been thrown overboard on the homeward trip. At any rate, the accident of hitting upon the precise locality of such relics is very curious. Otherwise than this instance we have rarely found in deep water any human traces except coal-cinders from steamers.

In all our ten localities between 2,000 and 3,000 fathoms, the bottom has been "globigerina ooze." We have never met with the "red clay" which ought to occur at such depths, according to the observations made on the cruise of the Challenger.

The temperatures observed with the improved thermometers now used on the Albatross were between 36·4° and 37·0° F., in 2,000 to 2,600 fathoms. But temperatures essentially the same as these were also taken in 1,000 to 1,500 fathoms, and even in 965 fathoms one observation gave 36·8°

F. It follows from these observations that nearly the minimum temperature is reached at about 1,000 fathoms, in this region.

The Zoological results this year are of great interest. Many additions to the fauna of great depths were made, and a large proportion of them are undescribed forms. Some of the fishes were of great interest. Huge spiny spider-crabs (*Lithodes Agassizii*) over three feet across were taken in 1,000 to 1,230 fathoms, and another very large crab (*Geryon*) occurred in great abundance in 500 to 1,000 fathoms, while in 2,574 fathoms a large and strong crab-like creature (*Munidopsis*) was taken. Many curious shrimp, some of them of large size and brightly colored, and often with perfect eyes, occurred in most of the deepest dredgings. Several very interesting new forms of star-fishes, ophiurans, and holothurians were dredged, some of them in large quantities, even in the deepest localities. Several interesting new forms of corals, gorgonians, sea-pens, and allied forms also occurred. Numerous specimens of huge sea-urchins with flexible shells (*Phormosoma uranus*) were obtained from several different stations, in 600 to 1,100 fathoms. Some of these are about ten inches broad. One sea-urchin (*Aspidodiadema*), not before observed north of the West Indies, was taken in 991 fathoms. Most of the deep-sea star-fishes belong to the *Archaster*, and other closely related genera. Some of these, like *A. Agassizii* and *A. grandis*, were taken in large numbers, several hundreds in a single haul. And the same often happens with several of the ophiurans and sea-urchins. One interesting stalked crinoid (*Rhizocrinus*) was obtained in 2,021 fathoms.

Many additions were made to the mollusca. In July, the writer published a general list of all the deep-water mollusca taken in the Gulf Stream region off this coast, up to the end of 1883. That list included 338 deep-water species and 42 that inhabit the surface waters. This year about twenty-five deep sea species and about eight from the surface were added to the list, making the total number over 400 species. Among the new forms discovered this year are four or five species of cephalopods, some of them very remarkable, and representing new genera. There were some very interesting new shells, some of them of good size and well developed, from below 2,000 fathoms. Most of the larger and finer ones from the very deep waters belong to the *Pleurotoma group*, but some large species are allied to *Sipho* (or *Fusus*) and to *Dolium*. Numerous specimens of three rare species of brachiopods were also dredged from below 1,000 fathoms. These are *Discina Atlantica*, *Waldheimia cranium*, and *Atretia gnomon*. The latter has not been known before from this side of the Atlantic.

[THE GARDEN.]

THE CATALPAS.

THERE are about half a dozen species belonging to the genus Catalpa, four of which are highly ornamental trees. These hail from North America, China, and Japan, and, in the south of England at any rate, can fairly claim to be classed among hardy subjects. The others, from the West Indies, are tropical plants, and therefore would be out of place here. C. bignonioides (the Catalpa, or Indian Bean) is by far the best known and most widely grown. Its panicles of large handsome flowers and the large light-green leaves give it a totally distinct aspect—one widely different from that of any other outdoor tree. Moreover, it flourishes even in the smoke laden atmosphere of towns, retaining its leaves after those of a good many other deciduous trees have fallen or become discolored. It is also a fast growing tree, and in its native country furnishes remarkably durable and valuable timber. The catalpas are readily raised from seeds or root cuttings.

*C. Bignonioides** has heart shaped leaves, pointed, downy

FOLIAGE OF THE CATALPA.

beneath, and the flowers are borne in open compound panicles. Its slender, nearly cylindrical seed pods are not unfrequently produced in the neighborhood of London. These measure about a foot in length, and remain hanging on the tree until the following spring. The bell shaped, two lipped corollas have an irregular five lobed spreading border; the color is white more or less tinged with violet and speckled with purple and yellow in the throat. It was first discovered by Catesby in South Carolina, and was introduced to this country in 1726. In a wild state, according to Professor C. S. Sargent's "Catalogue of the Forest Trees of North America," it occurs in Western Georgia, Florida, and perhaps west to Louisiana.

Its very light, close grained, remarkably durable wood is valuable for fence posts and cabinet work; its specific gravity when perfectly dry is 0·405. Under cultivation in this country it rarely attains more than 30 feet or 40 feet in height, but the Syon specimen figured by Loudon measured 52 feet in height and the trunk 3 feet in diameter, the spread of the branches being 50 feet. A noble tree in the garden of Mr. Denne Denne, of Canterbury, was figured in the *Gardeners' Chronicle* in 1876; this was only 32 feet high, but the branches had a spread of 60 feet. When in flower this tree resembled "a mass of snow, enlivened with rich yellow and brown mottlings." It would be very interesting to know how many of the catalpa trees mentioned by Loudon in his "Arboretum" are now in existence, and details of present measurements would be of great interest and value. This species no doubt attains a maximum size in rich, deep, somewhat moist soil, but it forms a very handsome tree, and flowers and grows freely in dry, sandy gravel. At Kew in very poor dry, gravelly soil specimens are now in full flower, and the large handsome leaves show no trace of the effects of the heat and drought which are only too evident in the case of several other deciduous trees.

Var. Aurea is one of the best golden leaved trees or shrubs in British gardens, as it retains its golden yellow hue throughout the season.

Var. Erubescens (Carriere, *Revue Horticole*, 1869, 460) is a form—probably a seedling from the common Indian Bean (C. bignonioides)—with a more compact inflorescence, larger, more highly colored corolla, with a less deeply divided limb.

C. Speciosa (Engelmann, in Coulter's *Botanical Gazette*, January 1, 1880).—This is a recent addition to British arboreta, and probably has not yet flowered in this country. It is, however, likely to prove valuable, and the following extracts from the late Dr. Engelmann's paper seem worth reproducing here: "This tree has quite an interesting and instructive history. It was already known to Michaux and to many botanists and settlers of those regions. Even the aboriginal Shawnees appreciated it, and the French settlers along the Wabash named it for them the Shawnee wood (Bois Chavanon), and prized the indestructible quality of its timber; but the botanists, even the subtle Rafinesque, who roamed over these very regions seem to have taken it for granted that it was not distinct from the southeastern Catalpa bignonioides. To me the fact that these trees, then not really cultivated in St. Louis, produced their larger and more showy flowers some ten or fifteen days earlier than the eastern or common kind was well known as early as 1842, and their blossoming has since been annually recorded in my notes on the advance of vegetation, but I had not the sagacity or curiosity to further investigate the tree. It was reserved to Dr. J. A. Warder, of Cincinnati, to draw public attention to it."

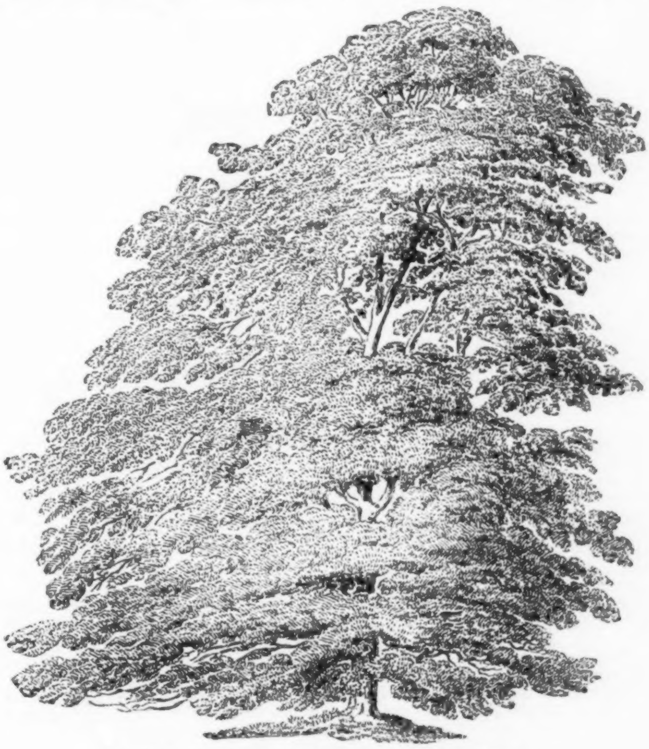
"Catalpa speciosa replaces C. bignonioides entirely in the Mississippi Valley. It is readily distinguished from it by its taller and straighter growth, its darker, thicker (half an inch to 1 inch), rougher, and scarcely exfoliating bark (in the older species it is light gray, constantly peeling off, and therefore not more than 2 lines or 3 lines thick); its softly downy, slenderly acuminate, and inodorous leaves (those of C. bignonioides have a disagreeable, almost fœtid odor when touched), marked with similar glands in the axils of the principal veins of the underside; by its much less crowded panicle, and by its much larger flower, fruit, and seed."

"Our tree is larger, of straighter growth, and being a native of a more northern latitude, is hardier than the southeastern species. The wood of both is extremely durable, perhaps as much so as that of our red cedar, and has the advantage over it of a more rapid growth and of possessing only a very thin layer (two or three annual rings) of destructible sapwood. But of these qualities and of its adaptability to many important uses others, and especially Mr. Barney in a recent pamphlet, have given a full account. It is already extensively planted in our Western prairie States, and especially along railroads, for which purpose it is expected to furnish the much-needed timber in a comparatively short time."

Professor C. S. Sargent, in correcting an error which had arisen in the *Gardeners' Chronicle* with respect to Catalpa speciosa, writes: "I take this occasion to call the attention of European planters to this species. It is in every way a far finer and more rapid growing tree than Catalpa bignonioides, and should it succeed in Europe, as from its geographical range in this country I am led to believe that it will, it will prove a most valuable addition to the list of ornamental and timber producing trees. Its distribution in a wild state is given by the same authority as Southern Indiana and Illinois, Western Kentucky and Tennessee, Southeastern Missouri, and possibly southward through Louisiana. Its wood is rather heavier than that of the last species, its specific gravity being 0·462; it is valuable for cabinet work, and almost imperishable when placed in contact with the soil; it is largely employed for railway ties, fence posts, etc. A large tree in rich bottom-lands, often 80 feet in height, with a trunk 4 feet in diameter; one of the most valuable trees of the American forests."

FLOWERING SHOOT OF CATALPA BIGNONIOIDES.

*C. Kæmpferi** is a native of Japan, where it was discovered by Kæmpfer in 1693, and introduced by seed into Belgium in 1849. It is a close ally of the American species already mentioned, and is one of the most striking of the many instances of that intimate relationship, due to common origin, of the plants of the Atlantic United States, and Eastern Asia, which is not shared by the plants of the Pacific Coast States. The leaves are smaller, cordate at the base, six inches long and broad, bright pale green; the round petioles measure from two to five inches in length. The panicle is erect as the leaves; the flowers are smaller than those of the American species, of a pale yellow color sprinkled with minute red spots. Probably this species hardly attains more than 12 feet in height.



A FULL GROWN CATALPA BIGNONIOIDES.

*C. bignonioides, Walter, "Flora Caroliniana," p. 64 (1788; Gray, "Manual of the Botany of the Northern United States," p. 321; Koch, "Dendrologie," zweiter theil, erster abtheilung, p. 398 C. syringifolia, Sims. *Botanical Magazine*, t. 1094; Loudon, "Arboretum et Fruticetum Britannicum," vol. iii., p. 1261; "Encyclopædia of Trees and Shrubs," p. 662.

* C. Kæmpferi, Siebold and Zuccarini, "Flora Japonica," sect. alt., p. 18; *Illustration Horticole*, 1862, p. 319. Koch, "Dendrologie," zweiter theil, erste abtheilung, p 306; *Botanical Magazine*, t. 6611. C. ovata, G. Don, "History of Dichlamydeous Plants," iv., 230. C. Bungei of gardens, not of C. A. Meyer. C. himalayensis of gardens.

C. Bungei,* a native of N. China, differs from those species previously mentioned in its racemose inflorescence, and nearly glabrous, generally entire, ovate, acuminate leaves. Now and then entire and lobed leaves are found on the same plant, and then it is the variety heterophylla. There is also mention made in catalogues of a variety nana, but C. Bungei itself is a dwarf shrub in British gardens, and at present I know too little of both type and so-called variety to determine whether they are identical or not. The flowers are described as greenish yellow with red spots.

GEORGE NICHOLSON.

Royal Gardens, Kew.

TRANSPLANTING.

AT no season of the year is the ground in a more suitable condition, both in respect to temperature and moisture, than it is at the present time, for transplanting all kinds of shrubs and trees. The humidity of the atmosphere is also much greater at this season than is the case in the spring months, there is consequently much less liability of exhaustion from excessive exhalation from the foliage and bark of newly transplanted trees. An additional advantage is also gained by transplanting at this season, from the fact that the earth temperature during the autumn months is a few degrees higher than that of the atmosphere; roots are thereby quickly developed, and the injury and check caused by transplanting is soon rectified, and the tree becomes re-established before winter sets in. Notwithstanding these advantages in favor of early autumn planting this work is frequently, from various causes, delayed till mid-winter or spring, and with very unsatisfactory results. Some planters, however, still maintain that, as regards evergreens at least, spring planting is preferable to autumn, but I venture to think that those who have formed such an opinion have failed to perform the operation sufficiently early in the autumn, as from this cause chiefly arises the failures we have so frequently to deplore. Such being the case, no time should be allowed to elapse where alterations and new plantations are contemplated; but every available means should be used to commence and complete the work as quickly as possible. Where large specimen trees or shrubs have to be transplanted, they should have received the necessary preparations six or twelve months previously by cutting a trench completely round and partially underneath them, so as to sever the roots at a proportionate distance from the stem, according to the size and nature of the tree. Many trees which furnish fibrous roots plentifully will succeed with a comparatively little ball of earth, but others, especially the Coniferæ and many tender kinds of evergreens, require a larger ball and greater care to insure success. In cutting this trench it is always advisable to save as many of the young healthy roots as possible by relaying them in the trench, and afterwards covering them with light rich soil, from which they can easily be removed without injury when being transplanted. Having thus prepared the tree, the site to which it is intended to remove it should receive attention. The first and perhaps the most important is to provide thorough drainage; without this few trees or shrubs will succeed satisfactorily. Where the subsoil is not sufficiently porous to prevent water stagnating at the roots, drains, rubble, gravel or ashes should be used for the purpose. The soil should be prepared according to the requirements of the tree. If it has grown well in its present position a similar kind of soil should, if possible, be used, with any addition which may be thought advisable for the changed position. Always avoid, when practicable, the removal of choice specimens from a very low-lying damp position to a high and dry one, and *vice versa;* still the latter precaution is not so important as the first, as from this cause alone innumerable failures occur in tree planting, nor does this remark apply to large specimens only, but also to shrubs, which seldom thrive if planted in a breezy, dry position after having been nursed in a damp, sheltered valley. Having made these essential preparations beforehand, and having the proper mechanical arrangements near at hand for conveying the tree to its intended position, care should be taken to injure the roots as little as possible in transit, and in placing it again in position. The roots should be laid out straight, and afterward covered with rather fine soil, which should be well washed down so as to prevent the soil from sinking afterward. A good mulching of half decayed manure—about three inches thick—should be spread over the surface, and if the tree be then made secure from wind, the operation will be complete.

In planting shrubs, although such precautions are not so essential, still the success resulting from skillful and careful practice amply repays for any extra time and labor incurred in the operation. Nothing is more disappointing and annoying to the planter than to see the majority of his newly planted shrubs fail to grow. Not only is the value of the shrubs lost, but the time and labor is also wasted, and, what is perhaps worse still, the effect produced is also disappointing. Early autumn planting and greater care in the operation are the two chief means to be used for remedying this evil. In planting new shrubberies a much better effect is produced by planting in large masses a few good and suitable kinds of shrubs than by planting in the indistinct, indefinite manner too often practiced. Variety must of course be considered, but it should be variety that will please, and not a meaningless medley which tends only to confuse and dissatisfy the onlooker. By planting in larger masses this advantage is also secured. The requisite kind of soil can be the more easily provided for any special kind of shrub, and the effect will be the better for this provision. In planting shrubberies the chief object to be attained should never be lost sight of; the selection of different kinds of shrubs should be in accordance with this object. Their nature, size, and shape should also be made subservient to it, nor should their ultimate size and character be permitted to go unheeded when the selection is made. If these few simple rules were attended to, how comparatively easy would the formation of shrubberies become, and how much more pleasing would the after effect be compared to many we are now accustomed to witness!—*T. S. C., in The Gardeners' Chronicle.*

PERENNIAL LOBELIAS.

FEW plants, if well cared for and grown in masses or groups, are more capable of contributing to the beauty of autumn gardens than perennial or herbaceous lobelias, and although a little fastidious as to position, very little management is needed in order to have them in perfection. They exist in most gardens in some form or other—from L. syphilitica and its numerous varieties to the handsome L. splendens—and although from various causes we do not always see them in the perfection which they are capable of attaining under liberal and proper treatment, enough is evinced to enable us to recommend their more general cultivation. The localities in which L. cardinalis, L. splendens, and others are found wild are generally moist, boggy, and wet places, and the absurdity of growing semi-bog plants in dry, sunburnt positions will be at once seen. Our experience with lobelias of this class in bogs and damp, partially shaded positions has been so far successful. They are said to be tender, but we have had no trouble with them in that respect. In winter we simply scatter a few ashes or cocoa-nut fiber over the crowns so as to protect the young growths from early spring frosts, and they succeed satisfactorily. Where a large stock is required early spring is the best time to lift the roots, which may then be divided into as many crowns as are needed. They should be potted singly in small pots, and where convenient, placed in a little heat until they begin to grow. They will flower freely the following season, and have much finer and larger flowers than those left undisturbed. They may also be raised from seed, which they ripen freely.

Varieties.—For garden purposes, L. fulgens, cardinalis, and splendens are about equal in merit, and it seems a waste of time to separate the three. Dr. Gray in his "Synopsis" describes the two last as distinct species, and no doubt they are in a wild state, but their garden descendants under good and careful cultivation are difficult to distinguish; indeed, in some instances, almost impossible. We have received seed of L. splendens true from the banks of the Arizona, California, and the produce of this is very distinct from that found in gardens, answering in all particulars to Gray's description; but when we take ignea, and compare it with some of the varieties of cardinalis, the line of demarkation is hard to draw. The following is Gray's description:

L. Cardinalis.—Minutely pubescent or glabrous, 2 feet to 4 feet high; leaves from oblong-ovate to oblong-lanceolate, tapering to both ends, irregularly serrate or serrulate, lower bracts leafy, tube of calyx and capsule hemispherical, much shorter than the subulate linear lobes; tube of the corolla about an inch long, the intense red of the corolla rarely varying to rose or even white. This species differs distinctly from L. fulgens in being devoid of pubescence, and also in having the divisions of the lower lip obtuse instead of lanceolate or acute. A very useful and showy plant, and one capable of improvement at the hands of florists.

L. Splendens.—More slender than the above, glabrous or nearly so; leaves lanceolate or almost linear, glandular denticulate, all but the lower sessile.

Under this species I am inclined to place the variety ignea and the so-called Victoriæ; the former I take to be a good

LOBELIA HYBRIDA; COLOR VIOLET PURPLE.

cultivated splendens; the latter the variety of splendens figured in the *Botanical Magazine* (t. 4002)—both very handsome and desirable plants. The plant represented by the annexed illustration is generally called L. hybrida, and is acknowledged to be the offspring of L. syphilitica on the one side and either L. fulgens cardinalis or splendens on the other—probably the former, because the same plant has been long known in gardens as L. fulgens var. violacea, L. speciosa, and L. Milleri. The color of the flowers is a beautiful violet, seemingly combining the bright red of fulgens with the rich purple of syphilitica. L. fulgens is a handsome, distinct, and striking plant; it differs considerably from all the others in having revolute margins to the leaves, and in the whole being downy and with a reddish instead of a purple stem.—*K., in The Garden.*

DAGAME—A VALUABLE WOOD.

AMONG the woods described by Estrada, in his account of his investigation of the more valuable Cuban woods* is the "*Dagame*" (Colycophyllum candidissimum). This tree is described as very plentiful on the island, as growing to a height of 40 to 50 feet, and squaring in short logs to about 12 inches. Its s. g. is 0·9, color pale yellow, grain fibrous, close, and fine, very like boxwood; it is strong, elastic, easily worked, turning well in the lathe; it is free from knots and takes a good polish, and is exceedingly durable. It is much used in Cuba for house framing, and to some extent for general joinery and for carriage and spar making.

The writer has taken occasion to verify this description of what seems to be one of the most valuable of the long list of remarkable woods described and tested by Estrada, and has been led to conclude that this wood is one that must, should it become well known in this country, prove to be the most useful of all our imported woods. Its extraordinary strength, toughness, and flexibility are accompanied by the most extraordinary perfection of elasticity. In the latter respect it far excels lancewood. Dr. A. M. Mayer has taken advantage of this latter quality in making application of the wood in the construction of fishing rods. The trout-rod, whether fly or bait, made of this wood has a perfection of elasticity and an absolute absence of "set," when bent, that is unapproached except by the best split bamboo. The wood may be imported at moderate cost from the West India Islands, and its introduction into the market will prove a very important matter to the engineer.

Estrada's figure for the tenacity of this wood is 13,000 pounds per square inch (1,914 kgs. per sq. cm.); in compressing stress from 10,000 to 12,000 (703 to 844); in transverse stress from 20,000 to 21,000 pounds per square inch (1,460 to 1,473 kgs. per sq. c.m.); and for the modulus of elasticity from 2,300,000 to 2,500,000 pounds per square inch (161,690 to 175,750 kgs. per sq. cm.)

The assertion of the investigator that "the native woods of Cuba, of which the specimens experimented upon are good representatives, possess qualities which render them superior, in every respect, to the hard woods of the United States or Europe, not only on account of their greater hardness, closer grain, finer texture, and greater durability, but also owing to their greater elasticity and strength," is fully borne out by these as well as by many other but slightly less remarkable sets of figures.

R. H. THURSTON.

Hoboken, October, 1884.

* C. Bungei, C. A. Meyer; De Candolle, "Prodromus," ix., 226; Koch, "Dendrologie," zweiter theil, erste abtheilung, p. 304.

* Van Nostrand's Mag., Nov. 1884.

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